A. M. A.
ARCHIVES OF
SURGERY

EDITORIAL BOARD

WALTMAN WALTERS, Chairman, Rochester, Minn.

LESTER R. DRAGSTEDT, Chicago

ROBERT ELMAN, St. Louis

ALTON OCHSNER, New Orleans

ARTHUR W. ALLEN, Boston

ALFRED BLALOCK, Baltimore

FRANK HINMAN Jr., San Francisco

G. E. LINDSKOG, New Haven, Conn.

BARNES WOODHALL, Durham, N. C.

RICHARD J. PLUNKETT, M.D., Chicago, Managing Editor

JULY 1952

VOLUME 65 NUMBER 1

Published Monthly by

AMERICAN MEDICAL ASSOCIATION

535 NORTH DEARBORN STREET • CHICAGO 10, ILLINOIS

Entered as Second Class Matter July 10, 1925, at the Postoffice at Chicago, Under the Act of March 3, 1879. Annual Subscription, $14.00

TABLE OF CONTENTS FIRST PAGE

from *Guatemala*

to Green Bay...

worldwide reports (NOW 1842)

worldwide acceptance

.. of one anesthetic

In 1934, when Abbott introduced its new ultra-short-acting barbiturate, intravenous anesthesia was not yet an accepted procedure. Now—18 years and over 1800 clinical reports later—PENTOTHAL Sodium and intravenous anesthesia have emerged as a drug and technique of choice in an ever-increasing number of major and minor surgical operations. • From the start, many anesthesiologists recognized the special merits of PENTOTHAL and intravenous anesthesia. Induction is rapid and pleasant. There is complete surgical amnesia and the patient usually awakens without nausea. The explosion hazard is obviated. PENTOTHAL requires no bulky, frightening equipment. And experience has shown that PENTOTHAL may be used in combination with other anesthetics to meet a specific patient requirement. • Write for more information on PENTOTHAL—investigate its potentialities in a wide range of applications, including obstetrics. Abbott Laboratories, North Chicago, Illinois. Abbott

Send for new book . . .

"PENTOTHAL Sodium by Rectum"

Thirty-six pages discussing the clinical value of PENTOTHAL by rectum for preanesthetic hypnosis and basal anesthesia—results from nearly 4000 cases.

Pentothal® Sodium

(Sterile Thiopental Sodium, Abbott)

FOR INTRAVENOUS ANESTHESIA

CONTENTS

Original Articles

Papers Read at Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Nov. 29-Dec. 1, 1951

(Concluded)

PAGE

Replacing Stomach After Total Gastrectomy with Right Ileocolon
Arthur J. Hunnicutt, M.D., Oakland, Calif. 1

Evaluation of Treatment of Hyperthyroidism with Radioiodine
Earl R. Miller, M.D.; Morris E. Dailey, M.D., and Horace J. McCorkle, M.D., San Francisco 12

Acute Massive Venous Occlusion
Eugene A. Osius, M.D., Detroit 19

Late Results of Inferior Vena Caval Ligations
Richard Zollinger, M.D., and Wells H. Teachnor, M.D., Columbus, Ohio 31

Hepatic, Splenic, and Left Gastric Arterial Ligations in Advanced Portal Cirrhosis
Jacob K. Berman, M.D., and James E. Hull, M.D., Indianapolis 37

Diagnosis and Treatment of Adenomatous Polyps of Colon
Russell R. Klein, M.D., and Robert A. Scarborough, M.D., San Francisco 65

Treatment of Extensive Prolapse of the Rectum in Aged or Debilitated Patients
W. A. Altemeier, M.D.; Jerome Giuseffi, M.D., and Paul Hoxworth, M.D., Cincinnati 72

Twofold Effect of Corticotropin (ACTH) on Blood Clotting and Its Implications in Surgery
A. B. McGraw, M.D.; R. R. Margulis, M.D., and B. E. Brush, M.D., Detroit 81

Blood Volume Studies in Thoracic Surgical Operations
Colonel James H. Forsee, Medical Corps, United States Army; Second Lieutenant Claude H. Schmidt, Medical Service Corps, United States Army Reserves; Joseph H. Holmes, M.D.; Edward D. Jenkins, B.A.; D. M. Huey, M.A., Denver, and Colonel John M. Salyer, Medical Corps, United States Army 88

Diaphragmatic Hernias with Visceral Complications
David H. Watkins, M.D.; Fred R. Harper, M.D., and William B. Condon, M.D., Denver 95

Silent Nontuberculous Lesions of Chest Disclosed in Survey X-Ray Studies
J. Dewey Bisgard, M.D., Omaha 109

Treatment of Mitral Stenosis by Finger Fracture Valvulotomy
Frank Gerbode, M.D.; Emile Holman, M.D., and Herbert Hultgren, M.D., San Francisco 113

Mitral Stenosis
Egbert H. Fell, M.D.; Oglesby Paul, M.D., Chicago; James A. Campbell, M.D., Albany, N. Y.; Carl B. Davis, Jr., M.D.; Louis Selverstone, M.D., and Robert Grissom, M.D., Chicago 128

Relief of Pain by Neurosurgical Procedures
Alfred W. Adson, M.D., and Hendrik J. Svien, M.D., Rochester, Minn. 139

(Continued on Next Page)

CONTENTS—Continued

PAGE

Surgical Care of the Neurologically Defective Infant
John Martin, M.D., Chicago 150

Management of Large Contaminated Wounds
Harvey S. Allen, M.D., Chicago 161

Nonunion of the Neck of the Femur
H. B. Boyd, M.D., Memphis, and H. H. Brindley, M.D., Temple, Texas 169

Sacrococcygeal Chordoma
Thomas J. Snodgrass, M.D., Janesville, Wis., and Henry M. Suckle, M.D., Madison, Wis. 181

Extra-Adrenal Abdominal Pheochromocytoma
John Homer Woolsey, M.D., and Woodring Pearson, M.D., Woodland, Calif. 188

Hindquarter Amputation
W. E. Leighton, M.D., St. Louis 195

Hemangiopericytoma
Robert A. Wise, M.D., Portland, Ore. 201

PERIODICAL PUBLICATIONS
of the American Medical Association

THE JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION—Weekly. Covers all the medical sciences and matters of general medical interest. Illustrated. Annual subscription price (three volumes): domestic, $15.00; Canadian, $16.50; foreign, $19.00. Single copies, 45 cents.

A. M. A. ARCHIVES OF INTERNAL MEDICINE—Monthly. Devoted to the publication of advanced original clinical and laboratory investigations in internal medicine. Illustrated. Annual subscription price (two volumes): domestic, $10.00; Canadian, $10.40; foreign, $11.00. Single copies, $1.00.

A. M. A. ARCHIVES OF NEUROLOGY AND PSYCHIATRY—Monthly. A medium for the presentation of original articles on nervous and mental diseases, with abstracts from foreign and domestic literature, book reviews, transactions of special societies, etc. Illustrated. Annual subscription price (two volumes): domestic, $12.00; Canadian, $12.40; foreign, $13.50. Single copies, $1.25.

A. M. A. ARCHIVES OF DERMATOLOGY AND SYPHILOLOGY—Monthly. Devoted to advancing the knowledge of and progress in cutaneous diseases and syphilis. Publishes original contributions on these two subjects, transactions of the important dermatological societies, book reviews, etc. Illustrated. Annual subscription price (two volumes): domestic, $12.00; Canadian, $12.40; foreign, $13.50. Single copies, $1.25.

A. M. A. AMERICAN JOURNAL OF DISEASES OF CHILDREN—Monthly. Presents pediatrics as a medical science and as a social problem. Includes carefully prepared reviews, based on recent pediatric literature, abstracts from foreign and domestic literature, book reviews, transactions of special societies, etc. Illustrated. Annual subscription price (two volumes): domestic, $12.00; Canadian, $12.40; foreign, $13.50. Single copies, $1.25.

A. M. A. ARCHIVES OF SURGERY—Monthly. Devoted largely to the investigative and clinical phases of surgery, with monthly reviews on orthopedic and urologic surgery. Well illustrated. Annual subscription price (two volumes): domestic, $14.00; Canadian, $14.40; foreign, $15.50. Single copies, $1.25, except special numbers.

A. M. A. ARCHIVES OF OPHTHALMOLOGY—Monthly. Includes original articles on diseases of the eye, annual reviews of special subjects, book reviews, transactions of special societies, etc. Illustrated. Annual subscription price (two volumes): domestic, $12.00; Canadian, $12.40; foreign, $13.00. Single copies, $1.25.

A. M. A. ARCHIVES OF OTOLARYNGOLOGY—Monthly. A medium for the presentation of original articles on diseases of the ear, nose and throat, with abstracts from foreign and domestic literature, book reviews, transactions of special societies, etc. Illustrated. Annual subscription price (two volumes): domestic, $12.00; Canadian, $12.40; foreign, $13.00. Single copies, $1.25.

A. M. A. ARCHIVES OF PATHOLOGY—Monthly. A periodical devoted to the publication of original articles and general reviews in the field of pathology. Illustrated. Annual subscription price (two volumes): domestic, $8.00; Canadian, $8.40; foreign, $9.00. Single copies, $1.00, except special issues.

A. M. A. ARCHIVES OF INDUSTRIAL HYGIENE AND OCCUPATIONAL MEDICINE—Monthly. Devoted to the advancement of knowledge of the diseases of industry and to the publication of scientific investigation in this field. Illustrated. Annual subscription price (two volumes): domestic, $8.00; Canadian, $8.40; foreign, $9.00, including postage. Single copies, $1.00.

QUARTERLY CUMULATIVE INDEX MEDICUS—A complete subject and author index to the worth while current medical literature of the world. Issued twice a year. Volumes bound for permanent reference. Subscription price, calendar year: domestic, $20.00; Canadian, $22.00; foreign, $22.00.

AMERICAN MEDICAL ASSOCIATION
535 North Dearborn Street CHICAGO 10

VARIATIONS IN DIAMETER
DECREASE TENSILE STRENGTH

ETHICON®
TRU-GAUGED
Surgical Gut

Ethicon's exclusive Tru-Gauging process provides remarkable uniformity of gauge and strength. *All* Ethicon Surgical Gut testing standards are far above U.S.P. minimum tensile strength requirements, permitting the use of smaller strands without sacrifice of suture strength.

ETHICON SUTURE LABORATORIES INCORPORATED

SUTURE LABORATORIES AT NEW BRUNSWICK, N. J.; CHICAGO, ILL.; SAO PAULO, BRAZIL; SYDNEY, AUSTRALIA; EDINBURGH, SCOTLAND.

COMPLETE ABSORPTION AT THE PROPER TIME

ETHICON *Surgical Gut*

Tru-Chromicized

minimizes foreign body irritation after the wound is healed

Ethicon Tru-Chromicized Surgical Gut provides a safe margin of suture-holding strength during wound healing—but digests soon after the suture is no longer needed.

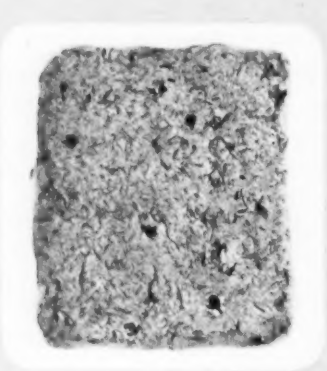
How Tru-Chromicizing Provides Safety and Reduces Irritation—In Ethicon's exclusive Tru-Chromicizing process, the individual ribbons of raw gut are chromicized *before* they are spun and dried. The chrome is evenly distributed and each portion of the strand, throughout the cross-section, has the same chrome content and enzyme resistance.

This more uniform chrome distribution not only assures maintenance of tensile strength throughout the normal healing cycle, but also provides an adequate safety margin for delayed healing. When the need for support has passed, *complete* digestion of the suture takes place.

Tru-Chromicizing permits the use of smaller sutures because Ethicon small sizes retain their holding power almost as long as larger sizes.

YOU COULD MAKE THIS SIMPLE TEST

Loops of gut were tied around a glass tube and immersed in 1% trypsin solution. After 200 hours (comparable to 6 months in tissue) the residue was spread on glass plates. Note the difference.



1. Ordinary surface chromicizing shows residue of undigested knots and suture fragments.

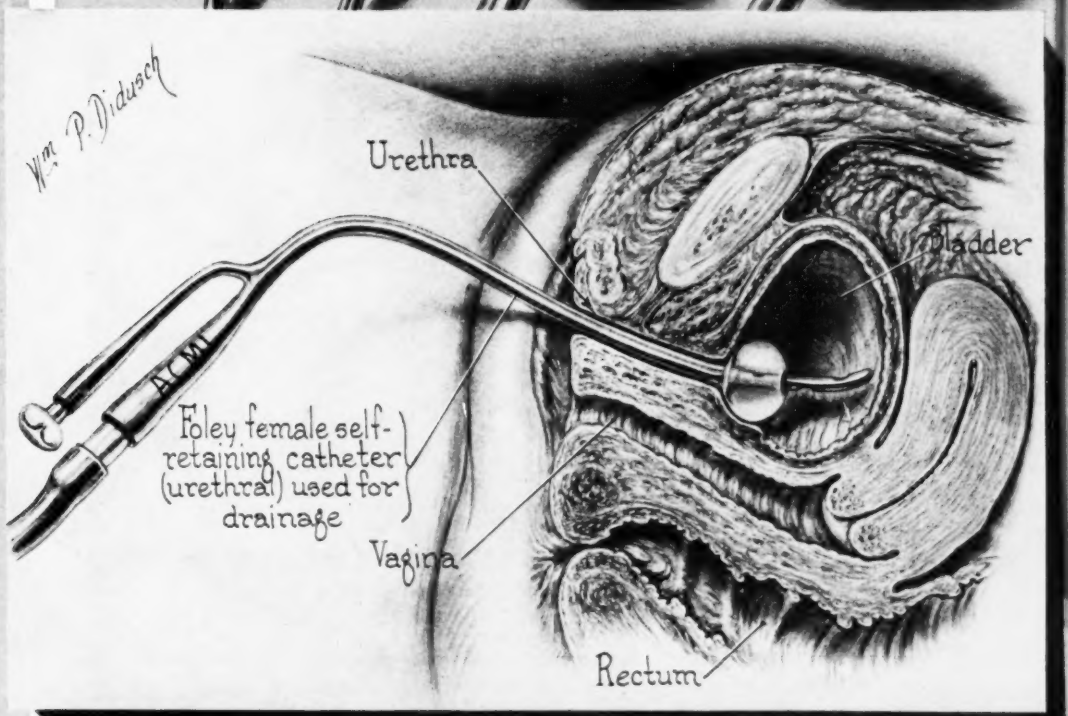
2. Tru-Chromicizing permits complete absorption, no undigested residue.

for dependable

HEMOSTATIC BAG CATHETERS

specify

A.C.M.I.



- *Uniform construction throughout catheter length*
- *Correctly marked for size*
- *Large lumen permits maximum drainage*

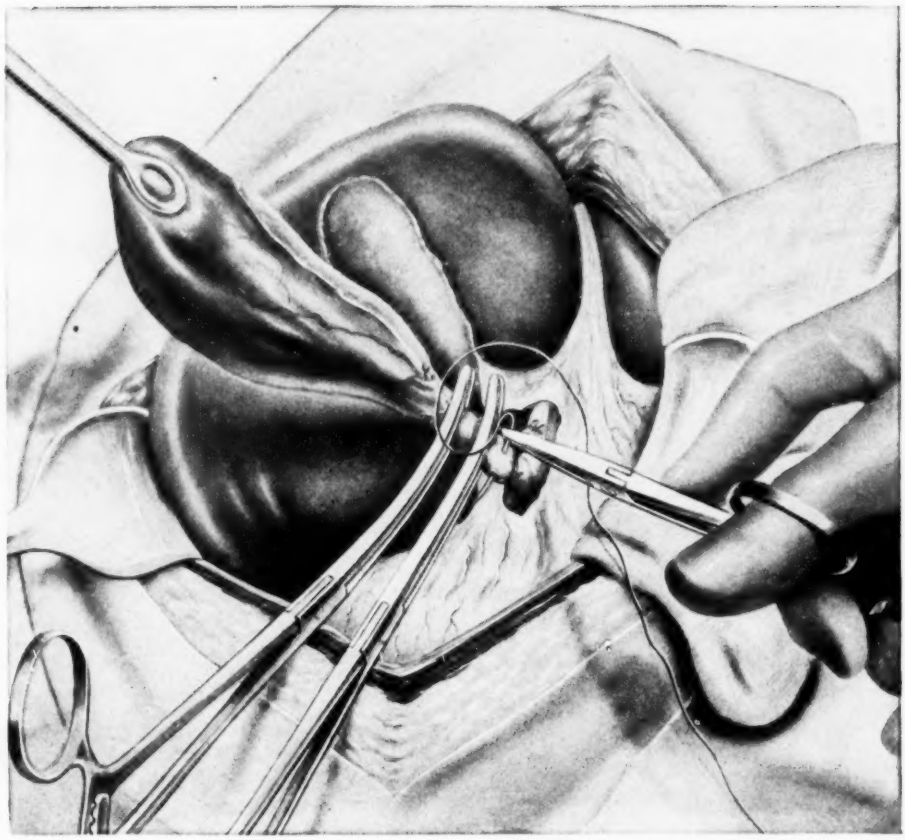
ESTABLISHED IN 1900 — BY REINHOLD WAPPLER

FREDERICK J. WALLACE, *President*

American Cystoscope Makers, Inc.

1241 LAFAYETTE AVENUE — NEW YORK 59, N. Y.

for this critical ligation **"timed-absorption"**



The success of a cholecystectomy depends on factors in the patient, in the surgical technic and in the suture material used. In a critical step, such as ligating the cystic duct, the skill of the surgeon must be supported by a dependable ligature, which will not digest prematurely.

"Timed-absorption" surgical gut assures a predictable digestion rate that can be measured.

By an exclusive improved process, D & G "timed-absorption" surgical gut is accurately tanned in *graded degrees* from the outer surface inward to achieve a more logical absorption curve. Maximum resistance to digestion is assured during *the critical first 4 days* when there is least fibrosis. As fibrosis develops and the need for artificial support lessens, the rate of absorption increases. The ligature on the cystic duct lasts until fibrosis is completed and finally absorbed.

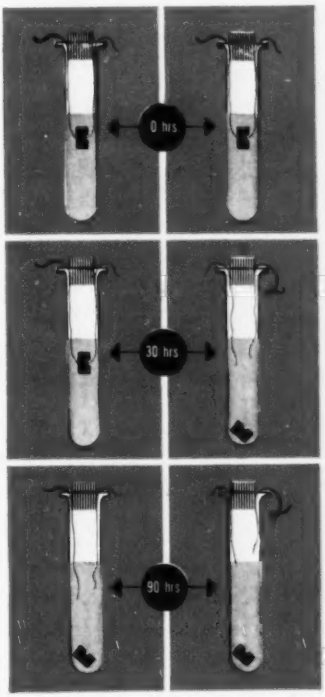
surgical gut sutures will not digest prematurely

90 hours vs. 30 hours

Comparison of D & G "timed-absorption" medium chromic surgical gut suture, size O, with non timed-absorption medium chromic surgical gut suture, size O. Weights are suspended from each in trypsin solution. Note that at the end of 30 hours "timed-absorption" surgical gut remains intact; the weight is still held suspended up to 90 hours. Contrast with non timed-absorption chromic surgical gut suture which has begun to digest and breaks under the slight tension created by the weight at 30 hours. In human tissue all chromic sutures are digested *more slowly*, but the ratio between the two types remains the same.

D & G surgical gut sutures have a special matte finish. They tie readily and do not slip at the knot. Pliability is exceptional and tensile strength, diameter for diameter, is guaranteed to be unexcelled by any other brand.

There is a D & G suture for every surgical purpose, available through responsible surgical supply dealers everywhere.



Davis & Geck "timed-absorption" sutures

non timed-absorption chromic sutures

"timed-absorption" sutures

Davis & Geck, Inc.

A unit of AMERICAN Cyanamid COMPANY

89 Willoughby Street, Brooklyn 1, N. Y.

Surgeons agree on D & G

To Minimize Emotional Trauma . . .
A Rapid and Bland Induction

VINETHENE®, administered by the simple and convenient open-drop technic, induces anesthesia swiftly and not unpleasantly. Recovery is rapid and the after-effects are minimal.

VINETHENE is a particularly suitable anesthetic:

for inducing anesthesia prior to use of ethyl ether for maintenance . . .
for short operative procedures . . .
for complementing agents such as nitrous oxide and ethylene.

Literature on request.

VINETHENE®

(Vinyl Ether for Anesthesia U. S. P. Merck)

AN INHALATION ANESTHETIC FOR SHORT OPERATIVE PROCEDURES

COUNCIL ACCEPTED

VINETHENE is a registered trade-mark of Merck & Co., Inc.

MERCK & CO., INC.
Manufacturing Chemists
RAHWAY, NEW JERSEY
In Canada: MERCK & CO. Limited—Montreal

A. M. A.
ARCHIVES OF SURGERY

VOLUME 65 JULY 1952 NUMBER 1

COPYRIGHT, 1952, BY THE AMERICAN MEDICAL ASSOCIATION

REPLACING STOMACH AFTER TOTAL GASTRECTOMY WITH RIGHT ILEOCOLON

ARTHUR J. HUNNICUTT, M.D.
OAKLAND, CALIF.

IN THE operation of total gastrectomy, replacement of the stomach with the terminal ileum and right colon appears to offer several advantages: (1) the ileocecal valve prevents regurgitation into the esophagus; (2) the transplaced right colon will accept an average-sized meal; (3) there are no apparent sensitivities of the right colon to ingested food, and (4) interposing the ileocolon between the esophagus and the duodenum with the resultant admixture of mucus to ingested food prevents or decreases adverse effects on the jejunum.

After it is determined that total gastrectomy is indicated and feasible, the terminal ileum and right colon are mobilized as if a right colon resection were contemplated. The terminal ileum is transected about 4 in. (10 cm.) from the ileocecal junction. The right colon is transected at or near the hepatic flexure, depending upon the variable right colic artery [1] (Fig. 1).

The mesentery of the right colon and terminal ileum, containing the ileocolic and right colic vessels, is then dissected proximally to the juncton of these vessels with the superior mesenteric vessels. The mesentery of the hepatic flexure and proxmal transverse colon should be mobilized to the superior mesenteric vessels. The continuity of the bowel is restored by an ileotransverse colostomy, anterior to the isolated right ileocolic mesentery. The right ileocolon and its mesentery when rotated superiorly then lie over the pancreas (Fig. 2). The rotation of the right colon can best be illustrated by placing one's right forearm and hand at one's side with the palm facing posteriorly. Let the extended thumb represent the terminal ileum. The radial side of the forearm then represents the mesenteric attachment on the right colon. If the palm is then placed on the chest with the extended thumb lying in line with the esophagus, it will be noted that the mesenteric edge would be cephalad and the mesentery would be posterior to the transposed colon. After removal of the stomach, an end-to-end anastomosis is then performed between the esophagus and the terminal 4 in. of the ileum and between the transected hepatic colon and duodenum (or jejunum, as in Case 1).

REPORT OF CASES

CASE 1.—Mr. H. C., aged 44, was operated on April 21, 1949, at Samuel Merritt Hospital.[2] About one month previously, March 18, I operated on the patient for a prepyloric lesion. Frozen sections revealed a sclerosing adenocarcinoma. Owing to the patient's condition on the table, I performed a high subtotal resection of the stomach, even though I knew that the carcinoma was beyond the line of resection. At operation on April 21 dense adhesions were present in the

The first four cases were presented before the San Francisco Surgical Society, Sept. 13, 1950.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Nov. 29, 1951.

1. Dr. John Saunders, Professor of Anatomy, University of California Medical School, made helpful suggestions on the physiology and anatomical variations of the right colon.

2. Preliminary report of first two cases was presented in 1949 (Hunnicutt, A. J.: Total Gastrectomy for Carcinoma: A New Procedure, Bull. Alameda Co. M. A., Sept. 1949, p. 16; reprinted, M. Rec. & Ann. **43**:1102 [Dec.] 1949).

upper abdomen. After considerable dissection I felt unwarranted in further attempts to isolate the duodenal stump. The remaining portion of the stomach and 1 in. of the esophagus were removed. The right colon and terminal 4 in. of the ileum were mobilized and rotated superiorly and anteriorly to the transverse colon. The ileum was anastomosed to the proximal jejunum in an anterior Polya manner, as shown in Figure 3.

One month later the patient was readmitted to the hospital, and an intra-abdominal abscess in the upper right quadrant was drained. This continued to drain as a duodenal fistula until his death on Aug. 7, 1949. Figure 4 represents the transposed right ileocolon which had been acting as a "stomach" for three and one-half months.

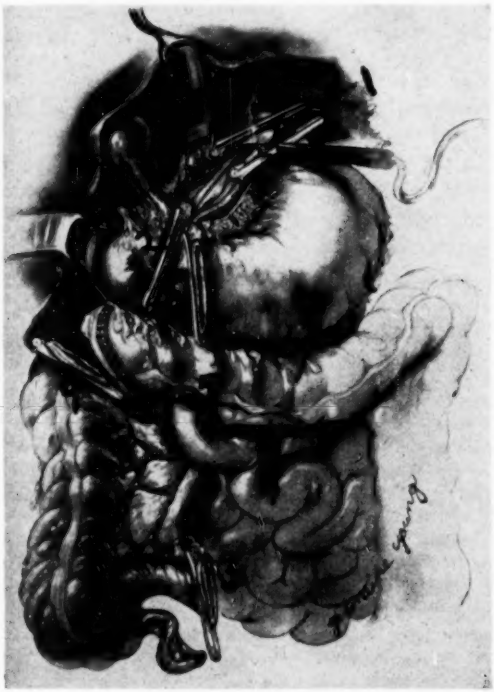


Fig. 1.—Illustrating removal of the stomach with transection of the esophagus (*1*) and of the duodenum (*2*). The ileocolon is mobilized (*3*) and (*4*). The base of the ileocolic mesentery should be narrower than illustrated in order to prevent kinking of the ileocolic vessels when rotation is carried out. An ileotransverse colostomy (*5*) is performed anterior to the mobilized right colon mesentery.

This is the only case in which the transected ascending colon was anastomosed to the proximal jejunum rather than to the duodenum. At autopsy, residual carcinoma was present in the duodenum; the patient's death was due to inanition from the duodenal fistula. The transplanted ileocolon was intact and had been functioning.

Case 2.—Mr. A. J. L., aged 61, was operated on May 11, 1949, at the Samuel Merritt Hospital. The lesion was an ulcerating Grade 4 adenocarcinoma on the lesser curvature measuring 3 by 12 by 15 cm. No carcinoma was present in the lymph nodes or lines of resection of the esophagus or duodenum. In this and the following cases the colon was anastomosed to the duodenum. The patient's postoperative course was rough. He was returned to surgery twice, once for small bowel obstruction and once for wound separation. He was then discharged from the hospital two weeks and two days after the primary surgery.

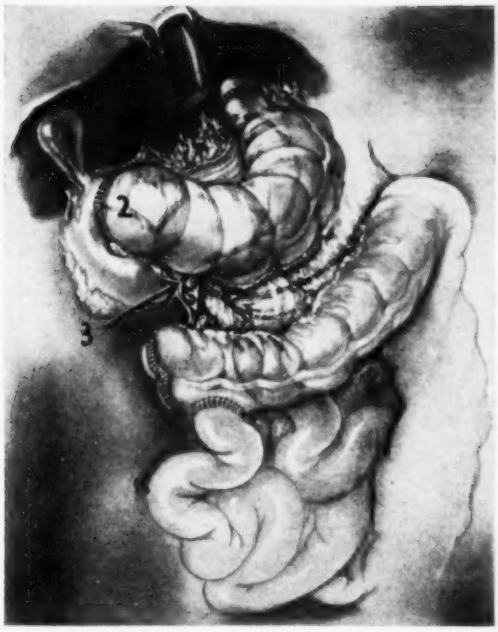


Fig. 2.—An end-to-end anastomosis was done between the esophagus and severed ileum (*1*) between the severed hepatic flexure and duodenum (*2*). The ileocolic mesentery (*3*) with the vascular supply lies posterior to the transposed ileocolon. The mesenteric border of the transposed ileocolon is cephalad, corresponding to the lesser curvature of the stomach. The cecum is on the patient's left, corresponding to the fundus of the stomach. Repeated measurements at autopsy during the two years prior to performing the first case revealed that the length of the ileocolic artery averaged 2 in. longer than the distance from the origin of the ileocolic artery to the diaphragm. The esophagoileal anastomosis can be performed 3 to 5 in. above the diaphragm without undue tension on the vascular supply.

Fig. 3.—Illustrating the procedure carried out in Case 1. *1*, anastomosis between esophagus and ileum; *2*, site of appendix; *3*, duodenal stump; *4*, anastomosis between ascending colon and jejunum, *5*, ileotransverse colostomy.

The patient's normal weight had been 145 to 150 lb. (66 to 68 kg.) with the highest weight 154 lb. (70 kg.). On release from the hospital he weighed about 123 lb. (56 kg.). He gained weight steadily, reaching 145 lb. (66 kg.) six months later, which he then maintained. He returned to work, was physically active, had normal health, ate a normal three-meal diet, and took no medicines of any kind. From time to time various laboratory data were obtained, as shown in the Table. One of the x-ray studies is shown in Figure 5. Periodic x-rays during the ensuing two years gave similar results.

*Summary of Data on Patient A. J. I. (Case 2)**

Laboratory Data	June 22, 1949	April 13, 1950	Oct. 19, 1950	April 25, 1951
Hemoglobin in gm./100 cc.	12.6 (75%)	13.7 (81%)	12.8 (76%)	13.2 (78%)
Red blood cell count	4,370,000	4,370,000	3,800,000	3,860,000
Color index	0.89	0.95	1.0	0.98
A/G ratio	.....	1.2/1	1.7/1	1.7/1
Serum chlorides, mg./100 cc.	.....	670	615	630
Serum cholesterol, mg./100 cc.	.....	240	210	202
Fasting blood sugar, mg./100 cc.	.....	.....	.....	89.0

* Patient A. J. I. was operated on May 11, 1949, and he died Aug. 11, 1951.

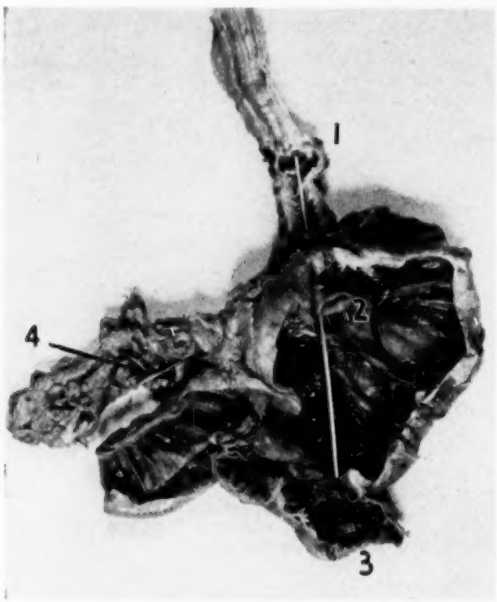


Fig. 4 (Case 1).—Autopsy specimen three and one-half months after surgery. The upper end of the arrow (*1*) is at the junction of the esophagus and ileum. It passes through the ileocecal valve at (*2*) and the lower end is at the end-to-side anastomosis between the ascending colon and jejunum (distal loop [*3*]); ileocolic mesentery and artery (*4*). The same surgical technique was used as in Figure 3.

In May, 1951, two years after surgery he complained of deep epigastric discomfort and loss of weight for one month. On May 4, 1951, in the course of removing a steel suture from the abdominal wall, I excised a biopsy specimen of the ascending colon. Figure 6 is a photomicrograph of the colon which had replaced the stomach for two years. It is interesting that it showed

no apparent change from normal. The patient died Aug. 11, 1951. At autopsy there was extensive retroperitoneal metastatic carcinoma, which had extended into the chest and obstructed the esophagus. Figure 7 shows the ileum and ascending colon which had replaced the stomach for two years three months.[2]

CASE 3.—Mr. C. J., aged 69, was operated on Feb. 3, 1950, at Alameda County Hospital. The lesion was a prepyloric medullary adenocarcinoma Grade 4 measuring 1 by 2 cm., with regional lymph node metastases.

The same technique was carried out as in Case 2. The patient's immediate postoperative course was smooth. He was ambulatory and eating on the fourth postoperative day. On the fifth day, abdominal pain and shock developed, and he died seven hours later. At autopsy there was a separation 4 mm. in diameter in the esophagoileal anastomosis, with generalized peritonitis.

CASE 4.—Mrs. G. B., aged 52, underwent operation on March 29, 1950, at the Samuel Merritt Hospital. The stomach contained an extensive scirrhous adenocarcinoma Grade 4, infiltrated to

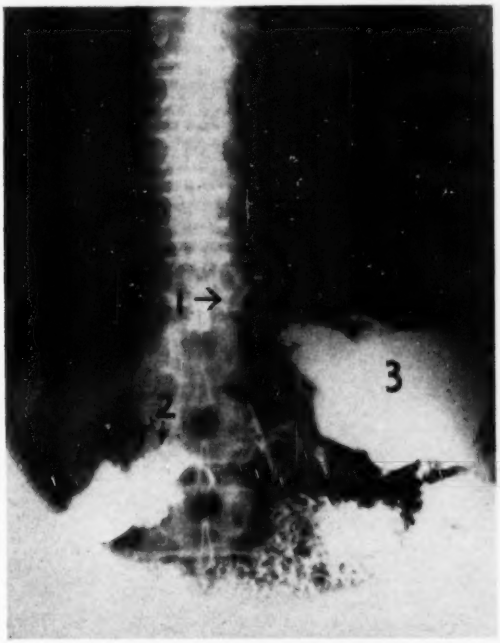


Fig. 5 (Case 2).—Roentgenogram taken 17 months postoperatively. *1*, anastomosis between esophagus and ileum; *2*, anastomosis between colon and duodenum; *3*, cecum.

X-Ray Report: The esophagus was studied with the patient both erect and prone and spot films were made to show the site of the anastomosis between the lower esophagus and the ileum and there was no indication of any delay or constriction at this site and the barium passes freely through into the artificial stomach. The appearance of the cecum and the ascending colon which represents the artificial stomach was very interesting in that the general contour closely simulates the stomach and at various times it could be seen to demonstrate evidence of peristaltic activity and it would empty itself through the site of the anastomosis into the duodenum and there is no indication of disease or deformity in the artificial stomach or at the site of the anastomosis between this new stomach and the duodenum. The duodenal loop is well outlined and it is of essentially normal contour. At the six hour visit there was small residue remaining in the stomach, but the barium had progressed well along through the intestinal tract.

ROBERT K. ARBUCKLE, M.D., Department of Radiology, Samuel Merritt Hospital.

the spleen and transverse colon. I removed en bloc the entire stomach, 1 in. (2.5 cm.) of the duodenum, and 2 in. (5 cm.) of the esophagus, and the spleen, omentum, transverse colon, and

mesocolon. Frozen sections showed no carcinoma in the transected esophagus or duodenum. The terminal ileum and right colon were interposed between the esophagus and the duodenum, as in the previous cases. The posterior attachment of the small bowel mesentery was freed and the embryological rotation of the small bowel was reversed in order to perform more conveniently an ileosplenic flexure colostomy. Five days after surgery the patient was eating and convalescing satisfactorily, then she started a discouraging downhill course and died May 5, 1950. At autopsy the ileocolon was observed to be intact and had been performing its new function. The entire peritoneum was studded with carcinoma implants 2 to 4 mm. in diameter. Residual carcinoma was present in both the distal esophagus and the proximal duodenum. The splenic, portal, and superior mesenteric veins were thrombosed (Fig. 8).

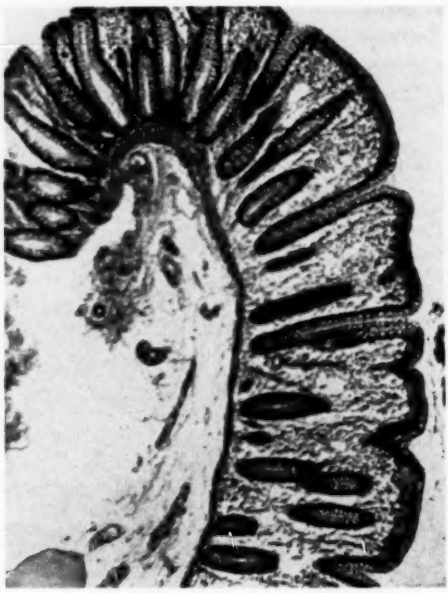


Fig. 6.—Photomicrograph of the ascending colon two years after replacement (Case 2). It is interesting that there was no change from normal. The muscle wall (not shown in this figure) showed no hypertrophy (Dr. Charles Baker, pathologist, Samuel Merritt Hospital). Similarly, no variation from normal was noted in sections of the transposed ileum and colon obtained from autopsies in Cases 1, 3, 4, and 5.

Comment.—The spleen was removed in all cases except Case 7.

Case 5.—Mr. E. O., aged 68, was operated on Oct. 9, 1950, at the Samuel Merritt Hospital. The gastric lesion was a scirrhous adenocarcinoma Grade 4 which had obstructed the esophagus. Although it was obvious that cure was not possible, a total gastrectomy was done together with the removal of the distal 2 in. of the esophagus and adjacent diaphragm, and gastric replacement by the terminal ileum and right colon was carried out in hopes of palliation. The patient died five days later, Oct. 14, 1950. Autopsy findings were pulmonary atelectasis and peritonitis with ileus. No breakdown of the various anastomoses was seen.

Case 6.—Mr. O. W., aged 61, underwent operation on May 7, 1951, at Palo Alto Hospital, Palo Alto, Calif. The gastric lesion was a Grade 3 adenocarcinoma 5 by 6.5 cm. The total gastrectomy with replacement by the terminal ileum and right colon was performed with minimal technical difficulties. The patient's convalescence in the hospital was slow and uneventful.

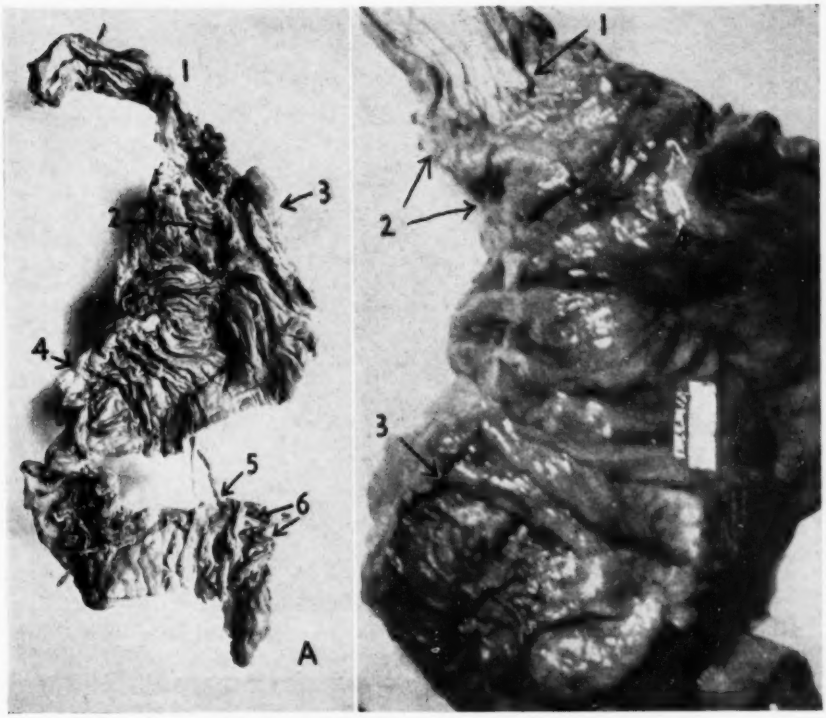


Fig. 7.—*A*, autopsy specimen from Case 2, two years three months after surgery. *1*, junction between esophagus and ileum; *2*, ileocecal valve; *3*, cecum; *4*, junction between hepatic flexure colon and duodenum; *5*, ileocolic vessels; *6*, superior mesenteric vessels and duodenojejunal flexure. Surgical technique is same as in Figure 2. *B*, same specimen before fixation and dissection. *1*, junction of esophagus and ileum; *2*, metastatic carcinoma with extrinsic obstruction of esophagus; *3*, junction of ascending colon and duodenum; *4*, ileocecal valve.

Fig. 8 (Case 4).—X-ray 14 days postoperatively. *1*, junction between esophagus and ileum; *2*, junction between hepatic flexure colon and duodenum; *3*, cecum.

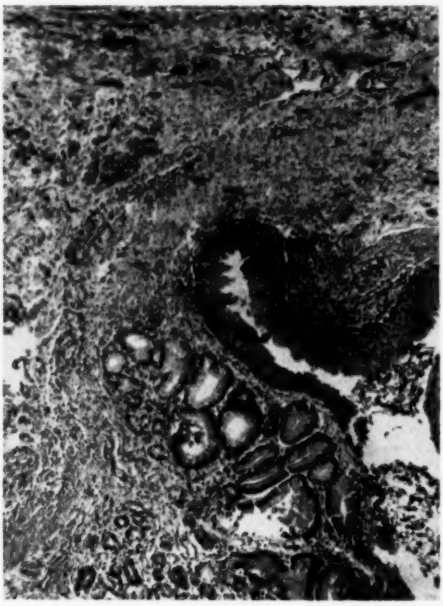


Fig. 9 (Case 4).—Photomicrograph of anastomosis of esophagus and ileum taken 37 days postoperatively from autopsy specimen.

Fig. 10 (Case 7).—X-ray taken 19 days postoperatively. *1*, junction between esophagus and ileum; *2*, junction between hepatic flexure colon and duodenum; *3*, cecum.

X-Ray Report: The examination of the upper gastrointestinal tract reveals complete removal of the stomach. The anastomosis between the distal ileum and the esophagus appears to be slightly narrowed and there is a small amount of barium which appears to be in a fistulous tract outside of the bowel. There is, however, no obstruction at the anastomosis and no dilatation of the esophagus proximal to the anastomosis. The cecum appears to be normal except for a small diverticulum just distal to the ileocecal valve. The anastomosis between the duodenum and the ascending colon functions well and there is no delay in emptying time of the cecum. In two hours the cecum is almost completely empty and at six hours there is no residual barium in the cecum. The small bowel appears to be normal and anastomosis between the ileum and the transverse colon functions normally.

R. F. Bunch, M.D., Department of Radiology, Providence Hospital.

For three months he was bothered with a "dumping syndrome" type of reaction, worse after breakfast, less severe after the evening meal. His normal weight had been 140 lb. (63.5 kg.). Before surgery he weighed 132 lb. (59.9 kg.). On June 20, seven weeks after surgery, he weighed 115 lb. (52 kg.). Since September, 1951, four months after surgery, this reaction to eating subsided. During the same month a nonobstructive hepatitis developed with low grade jaundice, presumably post transfusion. He was in bed on a medical regimen for three weeks. During October the hepatitis subsided. On Oct. 18, he weighed 108 lb. (49 kg), had returned to office work, and was slowly gaining strength. By Nov. 2, 1951, he weighed 113 lb. (51 kg.) and was eating well and enjoying his food.

CASE 7.—Mr. W. G., aged 73, was operated on Oct. 4, 1951, at Providence Hospital, Oakland, Calif. The gastric lesion was an ulcerating adenocarcinoma Grade 4 measuring 4 by 10 cm. A total gastrectomy and right ileocolon replacement between the esophagus and duodenum was performed. His convalescence was smooth and uneventful. He was given a liquid diet 5 days after surgery and an unrestricted diet 12 days after surgery. He enjoyed his food and had normal bowel elimination. Figure 10 is a roentgenogram taken Oct. 23, 1951, 19 days postoperatively.

This patient received a course of corticotropin for six days. The spleen was not removed. This is the only case in which the appendix was not removed.

An incidental and perhaps foreboding finding in the mobilized right colon was the presence of two polyps. These were removed.

COMMENT

Since 1949 other surgeons have performed this operation; their conclusions and results have been variable.[3]

Replacing the stomach with the ileocolon is extensive surgery involving three major "insults": gastrectomy, vagectomy, and ileocolon mobilization.

In September, 1949, at the Annual Seminar of the Samuel Merritt Hospital, Dr. Frederick Coller was the guest speaker. It was my privilege to go over these first two cases with him. In his discussion of this new procedure at the seminar, he made this pertinent comment:

> This operation is not designed to decrease the discouraging mortality in cancer of the stomach and time will have to evaluate whether it is worth putting the patient through this extensive procedure to attain the apparent added comfort and well being.

SUMMARY

Seven cases of total gastrectomy are presented in which the stomach is replaced by the right ileocolon. One of the two original cases is presented in more detail with a 27 month follow-up.

Time will have to determine whether the advantages of this operation will outweigh the extensiveness of the surgery.

DISCUSSION

DR. WHITFIELD CRANE, Oakland, Calif.: It has been my privilege over a period of several years to observe firsthand this remarkable procedure and also other technical surgical problems which I hope Dr. Hunnicutt will present at some later date.

In regard to this particular operation of replacing the stomach with the right colon, fundamentally it is designed to produce a better gastric function, and, as Dr. Fred Coller stated, time and experience will either prove or disprove its worth. From my own personal observations

3. Lawson, T. C., in discussion on Judd, E. S., Jr., and Hoon, J. R.: Total Gastrectomy: An Investigation of the Merits of End to End Esophagoduodenostomy, Arch. Surg. **61**:110 (July) 1950.

of Dr. Hunnicutt's cases, I am simply amazed that these people have no more digestive trouble than people with normal stomachs. The physiological result is indeed remarkable.

Now the question has been raised, as Dr. Hunt mentioned, as to whether or not it might not be simpler to use a portion of the transverse colon rather than the terminal ileum and cecum. There are several reasons which decidedly favor the latter procedure. Embryologically, we know that the midgut includes the stomach and the right colon. Miles said years ago that the cecum in many ways is like a second stomach. Therefore, the transverse colon is closer anatomically, though it is farther away physiologically. We also know that there is a definite to-and-fro peristaltic action in the transverse colon which is absent in the ascending colon. It is also known that the transverse colon makes only an artificial valve, whereas the ileocecal valve is a natural one. Last, the transverse colon is dirtier surgically than the ileum.

I feel that the author of this procedure certainly should be given a tremendous amount of credit for its painstaking development. In my opinion younger surgeons of this type with imagination and the will to work should be granted all the encouragement we can possibly give them.

DR. L. H. WILKINSON, Albuquerque, N. M.: So far as we have been able to determine, the case which we now report is the first case of extensive gastric papillary adenoma extending up into the terminal esophagus in which a total gastrectomy followed by transposition of terminal ileum and ascending colon has been done.

F. T., a 62-year-old Spanish-American man, was first seen in the outpatient clinic in August, 1951. He was complaining of epigastric fullness and discomfort after meals, which he had noticed for the previous three months. He complained of no definite abdominal pain and would not admit any food intolerance or loss of appetite.

A system review revealed no abnormalities except for the the fact that he had been having two to three bowel movements daily, instead of the usual daily movement. There was nothing unusual about the character of the more frequent stools.

Physical examination revealed a well-developed asthenic-type Spanish-American man, not acutely ill. On examination the head and neck were normal, except for badly infected gums and numerous carious teeth; the chest was normal on examination. The blood pressure was 110/70. Examination of the abdomen revealed a normal contour, with no masses, tenderness, scars, or herniae. Rectal examination revealed a small firm prostate and no palpable lesions.

Laboratory studies revealed the following findings: The urinalysis showed no abnormal findings. A complete blood count revealed 4,700,000 red cells, 11 gm. of hemoglobin, 23 γγ mean corpuscular hemoglobin, 8,300 white cells, with a differential count of 63% segmented cells, 31% lymphocytes, 1% monocyte, and 5% eosinophiles. The red blood cell count showed moderate central achromia. The sedimentation rate was 22 mm. per 60 minutes. The blood urea nitrogen value was 23 mg. per 100 cc., total protein level 5.2 gm. per 100 cc., and Wassermann reaction negative.

X-rays of the chest and colon were reported as normal. The gastrointestinal x-ray demonstrated a large filling defect on the greater curvature of the distal portion of the body of the stomach, interpreted as a probable malignant tumor of the stomach. X-rays of the gall bladder revealed normal function; no stones were present.

The patient underwent an exploratory operation for possible gastrectomy on Oct. 10, 1951. When the stomach was opened, an extensive papillary lesion was found involving the terminus of the esophagus and the entire body of the stomach to within a short distance of the pylorus. Frozen sections of several representative pieces of this lesion were interpreted as a benign lesion, but total excision was advised. A total gastrectomy was thereupon performed. The right colon and a small segment of terminal ileum were utilized as a gastric pouch. The pathological diagnosis was papillary adenoma extending from the gastric cardia to within 5 cm. of the pyloric canal and completely annular.

This case is presented because, so far as we can ascertain, it represents the first case in which the right colon has been utilized as a stomach pouch for a patient who did not have a carcinoma. It is hoped the patient will survive sufficiently long to permit long-term studies of changes in physiology following total gastrectomy.

The patient's convalescence was entirely uneventful, and at present his appetite is good and he has gained 2 lb. (0.9 kg.) in weight during the past two weeks.

DR. WILLIAM A. ALTEMEIER, Cincinnati: As frequently happens, various men may begin working on the same problem independently and in different areas. This particular idea apparently occurred at about the same time in California, Cincinnati, Italy, and England. In Cincinnati, Dr. Lee began his experiments on dogs in April, 1949. This was just about the same time that Dr. Hunnicutt did his first operation on the human. While Dr. Hunnicutt worked out the details of his procedure in the autopsy room, Dr. Lee developed them in the dog. The latter's work on dogs and a later report on three patients undergoing this operation for carcinoma of the stomach have been published. One of the patients died within 3 months after operation of intracranial metastases, another died within 14 months of extensive intra-abdominal recurrences, and the third is still living and well, having gained 25 lb. (11 kg.) in weight.

More recently, Fallis and his group at Henry Ford Hospital have reported three similar cases in which this operation was done. One of these patients is still living. In Italy, D'Errico proposed the transplantation of the tranverse colon after gastrectomy as the answer to this problem, but he did not actually perform the operation. Moroney, in England, however, did the procedure in patients undergoing gastrectomy for benign lesions.

The important point in all of this work seems to be the recognition of the necessity of a more radical approach to carcinoma of the stomach. As Zinninger has pointed out, carcinoma may spread for a considerable distance within the wall of the stomach and it may extend into the adjacent duodenum and esophagus. A recent survey has shown that recurrences develop at the site of the anastomosis in 75% of patients who undergo subtotal gastrectomy for carcinoma.

Dr. Hunt and Dr. Hunnicutt are to be congratulated for their vigorous attack toward the successful approach to this problem.

EVALUATION OF TREATMENT OF HYPERTHYROIDISM WITH RADIOIODINE

EARL R. MILLER, M.D.
MORRIS E. DAILEY, M.D.
AND
HORACE J. McCORKLE, M.D.
SAN FRANCISCO

THE TREATMENT of hyperthyroidism with radioiodine results from the intraglandular radiation therapy of the abnormal thyroid.

This report is concerned with the first 100 consecutive patients to whom radioiodine was administered for the treatment of hyperthyroidism at the University of California Medical School since the present radioiodine laboratory was established in 1945. The patients whose data are presented came from the thyroid clinic of the University of California Medical School and from private physicians. They were accepted for radioiodine treatment of their hyperthyroidism when in the opinion of referring physicians and the physician in charge of the radioiodine laboratory (E. R. M.) they had hyperthyroidism; they were not pregnant; there were no palpable nodules in the thyroid; they were apparently responsible enough to return for follow-up evaluation; they lived near enough to San Francisco so that the follow-up visits were not an undue burden, and they were not under the influence of antithyroid medication.

The evaluation of these patients' thyroid function before and after treatment was made by the physicians' analyses of the symptoms, signs, and results of the correlative laboratory procedures, such as determinations of the basal metabolism rate, protein-bound iodine, and I^{131} uptake in the thyroid. It is well to remember that there is no method available at present which will determine objectively the correctness of this evaluation. However, recent reevaluation of the records of these patients led us to believe that if they were to present themselves they would be accepted for treatment.

The first few patients were treated with small doses of radioactive iodine (250 to 400 μc of I^{131}) at weekly intervals. No untoward effects or notable successes were observed at this dose level. The dose was increased empirically. When effective apparatus was developed and adequate studies of the physical factors involved

From the Divisions of Radiology, Medicine, and Surgery, University of California School of Medicine.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Nov. 29, 1951.

This work was started under contract No. W-7405-eng-48-C and continued under contract AT-11-1-GEN-10, Project No. 2, both being contracts of the University of California with the United States Atomic Energy Commission. The work was supported in part by these contracts and in part by the University of California.

in radiation measurements were completed, the initial dose was changed to that amount of radioiodine which would deliver 3,000 beta rep to the thyroid. This radiation dose to the thyroid from the beta particles of I^{131} was calculated from the maximum uptake of the radioiodine in the gland, the effective half-life of the I^{131} in the thyroid, and the estimated weight of the thyroid. The initial dose was increased progressively until 6,000 beta rep was adopted as a routine initial dose. Since the first 100 patients were treated, further study of the I^{131} dosage problem has shown that there were considerable discrepancies between the planned treatment dose and the dose of radiation that the thyroid "actually" received. Because of these and other studies, the initial treatment dose of I^{131} was changed recently to 120 μc of I^{131} per estimated gram of thyroid. Subsequent treatment doses, if needed, were 60 or 120 μc per estimated gram of thyroid depending upon the clinical condition of the patient.

Patients suspected of hyperthyroidism and who may be treated with radioiodine arrive fasting at about 8 a. m. for a basal metabolic rate determination. At the conclusion of this procedure, they come to the radioiodine laboratory, where a blood sample for protein-bound iodine determination is drawn. They are given 50 μc of I^{131} and are permitted then to have breakfast. They return in one hour for the first determination of the per cent of the administered dose of the radioiodine that has reached the thyroid. Collimated scintillation counters are used at a 30 cm. distance for this determination. The radiation in counts per second from the thigh is subtracted from the radiation in counts per second from the neck. The difference is interpreted in microcuries of I^{131} in the thyroid from the known efficiency of the counters under these conditions. The clinical examination of the patient is then made by two physicians independently. Three hours after the I^{131} was administered a blood sample of 4 cc. is drawn in a heparinized syringe for the determination of the red blood cell : plasma I^{131} ratio by the method of Scott.[1] Determinations of the amount of I^{131} in the thyroid are made at three and at five hours. The patient is then examined by the physician in charge of the radioiodine laboratory, and all the data are studied. If there is doubt about the diagnosis, the patient is not treated. If the diagnosis of hyperthyroidism is confirmed, the patient receives the therapeutic dose of I^{131} and is permitted to return home. The patient is requested to return at four weeks for examination and at eight weeks for a total reevaluation. The latter is as complete as the first evaluation. The patient may be given additional treatment with radioiodine at the eight-week visit if such treatment seems necessary. The patient is followed until and after he is well.

The first patient in this series of 100 consecutive patients started treatment in September, 1945, and the last one started treatment in August, 1949. Thus the longest follow-up is over five years and the shortest follow-up is nearly two years. Of the 100 patients, 91 could be evaluated, and of these, 89 achieved remission and 2 were operated on or lost before they achieved remission. Among the 91 patients there was 1 who had a definite recurrence, 6 who had doubtful recurrences, and 10 in whom hypothyroidism developed. A patient was considered to have recurrence if he required further therapy for hyperthyroidism after having achieved remission from the disease following I^{131} therapy. Patients were considered to be hypothyroid if they were given treatment with thyroid extract for symptoms of hypothyroidism after remission of hyperthyroidism from the radioiodine treatment. Eight patients had clinical evidence of exophthalmos at the start of their treatment. Five of these recovered from their exophthalmos after treatment. In three others clinically significant exophthalmos developed after treatment. The series contains a relatively large number of patients with exophthalmos. These patients were chosen for treat-

1. Scott, K. G., and others: The use of I^{131} Red Cell Plasma Ratio as a Measure of Thyroid Function, Proc. Soc. Exper. Biol. & Med. **76**:592-595, 1951.

ment with radioiodine because previous experience has suggested that there was less likelihood of the development of progressive exophthalmos after treatment with radioiodine than after surgical treatment for hyperthyroidism.

Among these 100 patients there were 87 women and 13 men; their ages ranged from 2 to 65 years. Forty-nine had received one or more kinds of therapy affecting the thyroid from one month to several years before receiving treatment with radioiodine. Of these, 12 had had an operation, 29 had been treated with strong iodine solution U.S.P. (Lugol's solution), 11 with propylthiouracil, 3 with x-ray therapy, and 9 with thyroid substance by mouth.

Table 1 shows the doses in millicuries of I^{131} the 91 patients received by mouth for treatment of hyperthyroidism. It can be seen that the range of dose was

TABLE 1.—*Oral Doses of I^{131}*

Millicuries	Number of Patients
0- 1.9	5
2- 3.9	21
4- 5.9	18
6- 7.9	18
8- 9.9	11
10-11.9	8
12-18.9	6
22-26	4
	91

TABLE 2.—*Status of Patients as of January, 1951*

Year Therapy Started	Number of Patients	Unable to Evaluate	Achieved Remission	Lost to Follow-Up Still Sick	Lost to Follow-Up in Remission	Hypothyroidism	Recurrence	Death
1945	4	0	4	0	0	0	0	1
1946	26	3	22	1	3	2	? ?1	2
1947	35	2	33	0	10	2	1 ?1	0
1948	18	2	16	0	4	5	?2	0
1949	17	2	14	1	6	1	?2	0
Total	100	9	89	2	23	10	1? ?6	3

from less than 2 to over 22 mc., with the great majority of patients receiving doses between 2 and 10 mc. for the treatment of their disease.

Table 2 gives the status of these patients on Jan. 19, 1951. Three patients in the series died from causes not related to the thyroid or the therapy for hyperthyroidism. One died of tuberculosis in an insane asylum two and one-half years following the last dose of I^{131}; one died five years after the last dose of I^{131} of aplastic anemia following methylphenylethyl hydantoin (mesantoin®) therapy for epilepsy, and one patient died four years after the final I^{131} therapy from postpartum idiopathic acute yellow atrophy of the liver.

Patients treated for hyperthyroidism with I^{131} were considered to be in remission when in the opinion of the physicians treating the patients there were no longer symptoms or signs of hyperthyroidism, the thyroid had apparently returned to normal size, and the laboratory findings no longer suggested hyperthyroidism even though the patient might have hypothyroidism or exophthalmos.

Table 3 gives the time after initial I^{131} therapy required for achieving remission in 89 patients who did achieve such remission.

The basal metabolic rates at the time of their initial I^{131} treatment ranged from +14 to +64%, with a median of +38%. The median basal metabolic rate reached +10% three months later and reached normal four and a half months later.

The estimated thyroid weights of those patients at the time of initial treatment with I^{131} ranged from 10 to 100 gm., with a median of 35 gm. The median value was 20 gm. in 3 months and 10 gm. in 10 months.

TABLE 3.—*Time Required for Remission in 81 Patients*

Time for Remission After Beginning Therapy	Number of Patients
Less than 2 months	16
Less than 4 months	50 (56%)
Less than 6 months	63
Less than 8 months	70 (79%)
Less than 10 months	78
Less than 12 months	79
Less than 14 months	83
Less than 22 months	85 (90%)
Less than 30 months	87
Time unknown*	2

* These two patients were lost from observation after their last dose and were later traced and found to be well without further treatment.

TABLE 4.—*Number of Doses of I^{131} for Hyperthyroidism*

Doses, No.	Patients	
	No.	Cumulative Total
1	29	29 (32%)
2	33	62 (68%)
3	12	74 (82%)
4	8	82 (90%)
5	0	82
6	4	86
7	3	89
8	2	91

The protein-bound iodine values at the time of initial treatment ranged from 5 to 22 γ per 100 cc., with a median value of 10 γ per 100 cc. The median value for protein-bound iodine was 8 γ per 100 cc. in two months and 6 γ per 100 cc. in four months after I^{131} treatment.

The literature now contains many articles dealing with radioiodine and its use in thyroid study and disease. While I^{131} dosage calculation and schedules differ in the hands of various workers, the results of treatment of hyperthyroidism are essentially the same in nearly all of them. No untoward effects have been observed in these patients. The greatest danger from the radioiodine treatment of hyperthyroidism is the possibility of malignant change. The radiation from radioiodine administered to a patient by mouth reaches all parts of the body. It is concentrated mainly in the thyroid, but more than the body average of radiation is also given to the stomach, salivary glands, and kidney. All these organs have been subjected in the past, in conventional radiation therapy, to doses in excess of those used for

the treatment of hyperthyroidism by radioiodine without development of malignancy. As compared with the treatment of toxic diffuse goiter by surgery, the treatment of hyperthyroidism with I^{131} spares the patient the expense of hospitalization, the scar, the fear, and the risk, however small, of nerve injury, parathyroid injury, postoperative hemorrhage, and anesthesia.

SUMMARY

Data from 100 consecutive patients treated with radioiodine for hyperthyroidism at the University of California School of Medicine were presented. Of the 91 cases that could be evaluated, remission was achieved in 89, 1 was lost to follow-up and operation was done in 1 before remission was achieved, in 1 there was definite recurrence and in 6 doubtful recurrences and in 10 hypothyroidism developed, necessitating treatment with thyroid substance. The follow-up period is from one and one-half to more than five years since the beginning of treatment. No untoward effects have been observed.

The editor of *Radiology* granted permission to reprint Tables 1, 2, and 3 from "Studies with Radioiodine: II. Treatment of Patients with Hyperthyroidism by I^{131}," by Earl R. Miller, M.D., and others, appearing in the August, 1951, issue of that journal.

DISCUSSION

Dr. H. H. Searls, San Francisco: I have enjoyed studying Dr. Miller's paper and listening to his presentation of it here this morning. As a member of the Thyroid Committee of the University of California School of Medicine, I have participated in the selection of many of the patients included in this series. Together with other surgeons in this group, some of whom are co-authors of this paper, I believe that an open mind was maintained during the examination of the various patients and their assignment to this series for a medical type of treatment. Dr. Miller's background of training as a physicist as well as a medical man always results in crystal-clear statements of factual findings and coldly logical deductions. It is very stimulating to a group of clinicians to associate with a man whose mind works in this manner. As clinicians we have been trained to draw deductions from certain scientific assumptions and to accept a clinical picture which Dr. Miller throws out as not securely based on fact. Such a situation is found in the syndrome described by Graves. Because its cause is not known and because sufficiently pathognomonic laboratory tests have not been devised to establish the diagnosis, he is reluctant to accept it as a clinical entity.

The research described to you this morning by Dr. Miller has been done under the most completely controlled program that it was possible to obtain. His results are striking. That a patient may take a single drink of a clear, tasteless liquid and in a few months be relieved of the vicious symptoms of a severely toxic exophthalmic goiter and return to a normal condition of well-being and an unqualified way of life is, indeed, theatrical. The follow-up has been fairly complete and shows that a high percentage of patients remain euthyroid.

In the ideal circumstances of a carefully controlled radionic laboratory directed by properly trained personnel, treatment of toxic diffuse goiter by radioactive iodine offers results parallel to those obtained under the best conditions by subtotal thyroidectomy. Laboratories so equipped and manned are few and far between in this country. The therapeutic agent employed is not available except in such places. Its uncontrolled administration cannot be considered. Even in the best hands there are contraindications to its use. It probably should not be administered to young persons or to pregnant women. Except where research projects finance the cost of the treatment, as was done in this study, it would prove to be a rather expensive form of therapy. It is my belief, therefore, that this interesting method of control of the symptoms of toxic diffuse goiter will remain more or less a research activity and that subtotal thyroidectomy in the hands of the properly trained surgeon will continue as the procedure of choice throughout this country.

DR. GEORGE M. CURTIS, Columbus, Ohio: I want to show two slides, one concerning the first paper, by Dr. Kearns, and the other concerning the second paper, by Dr. Miller.

[Slide] This is an example of the modern radioautograph which we are using for our sections of goiters as removed surgically. The section on the left is from a patient with Graves's disease of the thyroid, often known as diffuse hyperplastic goiter with hyperthyroidism. This young woman's basal metabolic rate was not so high; so we prepared her by the old method, which we used at the Presbyterian Hospital in 1920 and 1921 without giving iodine, and we watched her carefully. However, we do not recommend that procedure.

She was given less than 1 mc. of radioactive iodine (I^{131}) 15 hours before operation and the thyroidectomy was uneventfully accomplished. The thyroid removed was taken at once to the laboratory, fixed and embedded in celloidin, and sections were then cut. The two celloidin sections are shown at the left. Those celloidin sections, as you may see, present the diffuse hyperplasia. The section was then laid on this ultrasensitive photographic plate and left there for some days. The plate was then developed and examined under the microscope. You should remember that this is an autograph made from a microscopic section. What you see on your right was an amazing finding, rather like that when man first looked at his hand under the fluoroscope and then took such an x-ray picture.

You will notice one thing that shows in the radioautograph, which is also shown in the corresponding histologic section on the left. There is no evidence of radioactive iodine within the thyroid cells. When the original study was made, it was thought that the radioactive iodine (I^{131}) lodged only in the thyroid cells and that they were irradiated in that way. The reason was that only a short time had elapsed between the giving of the radioactive iodine and finding it in the cells. Within 15 hours it is almost all within the colloid, which is an ideal condition for its use in the treatment of patients with exophthalmic goiter because as it goes into the colloid, it is fractionated into diiodotyrosine and thyroxine iodine. This colloid, at the present time, has radioiodine, and the radiation from it is not only a gamma radiation but also a beta radiation, which is a very short-length efficiency radiation. The principle is there certainly, but there are also other factors present. One of the other things which one finds in making these studies is that a radioactive hormone goes at once into the circulation. Within twenty-four hours we find radioactive thyroid hormone in the circulation. I have listened to men say time and again that they find nothing abnormal. I wonder if they are following their cases long enough or following them with adequate methods.

I am a little concerned about the long-range effect of radioactive iodine as well as its end-effects. I do not believe that at the present time we can plunge into that, because, frankly, we simply do not know enough.

In the treatment of thyroid cancer, as Dr. Kearns brought out so clearly, it differs when the radioiodine is not lodged in the colloid. The treatment is not the same as in the differentiated case where there is better chance to store radioiodine and so irradiate the tumor cells. You get different pictures in this autograph that you don't get at all in the treatment of the nodular thyroid. The effect that you get if it is true Graves's disease is this, such as you see in this slide.

[Slide] A number of years ago we were determining the total iodine balance. We were determining, first, the small amount of iodine which is in the intake. You see, the small amount of intake iodine. In this column you may also see the amount in the urinary as well as in the fecal excretion. These are three-day periods, showing intake and excretion balance. The balance is negative when the dark figure is below the line [indicating on slide], and the balance is positive when the figure is above the line. Now this patient, with a toxic nodular goiter, was given a low iodine intake on purpose. You will notice that the urinary excretion was far greater than the intake and that the balance was definitely negative. We have made a number of metabolic studies and have recorded them, and find that the patient with a toxic nodular goiter has a metabolic rate which is increased; also, more thyroxin is also broken down and excreted. This means that the patient does not take in enough iodine, resulting in the negative iodine balance which you see here. After thyroidectomy, you will find in any patient with a toxic goiter this sort of change in balance in the urine and feces. I won't go into that, since it has already been reported, but in 9 to 12 days the metabolic

rate and iodine balance in this patient with toxic goiter is back to normal. I don't know of any other available method at the present time which will control this metabolic anomaly present in hyperthyroidism so rapidly as that factor is concerned.

My point with regard to radioiodine is this: Most of the cases which we are studying at the present time are cases of various types of carcinoma with an accompanying hyperthyroidism. We expect to learn from them.

I am frankly concerned whether in these cases we are really seeing what is going on from the standpoint of radiation effects upon the other tissues. We don't know.

I am certain that Dr. Miller knows about Brown's book "American Martyrs to Science Through the Roentgen Rays"; I only hope that another such book will not have to be written about isotopes. It has been stated that the therapy involves only a little clear water to drink and so forth; yet, as I remarked at the meeting of American College of Surgeons in Los Angeles, "We must still be careful of the historic consequences of a little drink."

Dr. Arnold Jackson, Madison, Wis.: These are two splendid papers which naturally are of great interest to me. I think that the first speaker mentioned the fact that the solitary adenoma is only a clinical entity. I congraulate him on that. There is a growing tendency to speak of solitary adenomas, and, gentlemen, there is no such thing. If one looks far enough, one will always find multiple adenomas. Clinically there may be a large distinct adenoma, but pathological examination will nearly always show multiple adenomas. In talking last week with Dr. William McCarty, emeritus professor of pathology of the Mayo Clinic, he said, "If you will look far enough in the thyroid adenoma case, you will always find multiple adenomas."

It has been my good fortune to have followed the work of Dr. Miller, and I have gone to San Francisco and taken part in discussions on the subject of radioactive iodine. I am sure that even the most conservative men discussing this subject believe that Dr. Miller's work offers great promise. It has been discussed at the meetings of the American Goiter Association, an organization which comprises not only surgeons but internists, pathologists, and biochemists, all interested in the subject of radioactive iodine. I think the consensus probably would corroborate the statements of Dr. Curtis. Men like Dr. Frank Lahey and Dr. John Pemberton, who have every facility to use it, believe that subtotal thyroidectomy, rather than radioactive iodine, is the method of choice in treating this disease.

One more point: When we speak of radioactive iodine in the treatment of hyperthyroidism, we must, of course, differentiate between toxic nodular goiter and Graves's disease. While the radioactive iodine will reduce the metabolic rate it will not remove the nodular goiter, and we know all the complications which may develop from that.

Dr. J. E. Kearns, Evanston, Ill.: In conclusion, I wish to thank the two excellent thyroidologists, Dr. Curtis and Dr. Jackson, for their discussions. The only debate I have with Dr. Jackson is that it was not Dr. McCarty but Dr. Allen Graham. Also, as Dr. Curtis demonstrated in his illustrations, we chose a multiple method of treatment of carcinoma of the thyroid, hoping that by this method more radioactive iodine would get to the thyroid more frequently.

There are a few points in Dr. Miller's paper upon which I should like to enlarge. The advancement in the treatment of diseases of the thyroid has been largely surgical. I don't feel that one needs to apologize for reporting work on its treatment with radioactive iodine at a surgical meeting. We have used radioactive iodine in treating patients with Graves's disease. We have found that external survey is of no value in evaluating whether the patient is toxic because such an examination shows only a hyperplasia of the gland. This can occur in a woman at the time of pregnancy or at the time of menstruation in a patient with goiter, and in a patient with infection. It does assist, when you have made a clinical diagnosis of Graves's disease, in evaluating your dosage, also that the size of the thyroid means nothing, because clinically you can miss it 100 per cent one way or the other and it has nothing to do with the severity of the disease. I give the therapy by hazarding a guess at size, uptake, and on previous surgical experience with this type of patient. It has aided a great deal in treating with radioactive iodine. One can never talk of a cure whether treated by surgery, x-ray or ionizing radiation. It always is a remission. I am sure that Dr. Curtis, Dr. Jackson, and Dr. Shivers have all seen the patient with a recurrence twenty or thirty years following subtotal thyroidectomy.

ACUTE MASSIVE VENOUS OCCLUSION

EUGENE A. OSIUS, M.D.
DETROIT

ACUTE massive venous occlusion has recently received increasing attention, although references to it in the literature have appeared since 1593, when Fabricius Hildanus [1] reported and described such an entity even to the details of gangrene. (He also reported and described congenital pyloric stenosis.[2]) Cruveilhier,[3] while recognizing this feature as an accompaniment of venous occlusion, pointed out that the incidence of gangrene was not large. He stated that gangrene cannot develop in the absence of extensive and complete venous occlusion. It was not until 1937, however, that the essential features of this complication were made clear by Fontaine and de Sousa-Pereira.[4] They showed that complete ligation of the venous circulation in the leg of the dog produced gangrene, just as in the intestine. It was also shown that the process might be arrested at any stage, and hence that the condition does not in all cases progress to the stage of gangrene with loss of limb, digits, or even life. The accompanying diagram may illustrate the mechanism of partial or complete venous occlusion (Fig. 1). A partial block results in slowing of the blood stream, partial anoxia due to decreased exchange rate of oxygen, and actually a slowing of the traffic. The complete occlusion, on the other hand, accentuates this to the point of complete stasis and finally asphyxiation of tissues and death of the part, even though the arteries and arterioles may not be thrombosed. Laufman and others [5] have further confirmed the existence of this mechanism when they showed that:

1. Vasospasm generally accompanies main-stem vascular occlusions.

2. In venous occlusion there is a marked arterial spasm (decreased caliber) and a venous dilatation (increased caliber).

3. Following release of venous occlusions, the artery remains in a state of moderate spasm for a considerable period of time. We have termed this phenomenon *residual spasm.*

4. In arterial occlusion there is a marked arterial spasm and a concomitant venous spasm.

From the Department of Surgery, Harper Hospital.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Nov. 30, 1951.

1. Fabricius Hildanus, G.: De gangræna et sphacelo, Cologne, 1593.

2. Fabricius Hildanus, G.: Opera omnia, Frankfurt, John Bejerus, 1646, Chap. 6, Abstract 34, p. 541.

3. Cruveilhier, J.: Traité d'anatomie pathologique générale, Paris, J. B. Baillière et fils, Vol. 4, 1862, p. 288.

4. Fontaine, R., and de Sousa-Pereira, A.: Oblitérations et résections veineuses expérimentales; contribution à l'étude de la circulation collatérale veineuse, Rev. de chir., Paris **75**:161-200 (March) 1937.

5. Laufman, H.; Martin, W. B., and Tuell, S. W.: The Pattern of Vasospasm Following Acute Arterial and Venous Occlusions: Micrometric Study, Surg., Gynec. & Obst. **87**:641-651 (Dec.) 1948.

5. Following release of arterial occlusions grossly visible reactive hyperemia occurs, but during this state the precapillary artery remains in spasm.

6. Sludge formation (Kniseley) is seen in the smaller vessels during both arterial and venous occlusions. Minute thrombi form easily in the spastic vein during arterial occlusion and may propagate, thus accounting for segmental venous thrombosis in arterial occlusive disease. This observation makes it unnecessary to postulate the presence of periarterial inflammation as a venous irritant in the production of venous thrombosis.

7. Reactivity in a small vessel becomes arrested once the vessel is thrombosed.

8. The importance of vasospasm in the phenomena accompanying vascular occlusions in general is emphasized.

Massive venous occlusion, accordingly, is a sudden and complete block to the venous outflow and as such should produce main-stem vasospasm. Being venous occlusion it should produce arterial spasm and venous dilatation with venous sludge formation and propagating thrombosis. If prolonged, the arterial vasospasm may result in tissue asphyxia and consequently gangrene. This is exactly what happens in acute massive venous occlusion. The interesting fact is that this state may reach serious and disastrous proportions and not only may a part become gangrenous but the entire organism may succumb and die. In DeBakey and Ochsner's [6] collected series of 32 cases there were eight deaths. This series included six pulmonary infarcts with one death. Another series of 27 by Haimovici [7] had 11 deaths. Acute massive venous occlusion has a high mortality rate, and gangrene is not an uncommon complication. Loss of an extremity or its parts is threatened in each nonfatal case, and the long-range sequelae of venous thrombosis are constant threats.

Many etiologic factors have been claimed, but, as may be expected, these are colored by individual experience since few surgeons have seen large numbers of cases. It is the opinion of many that infection plays a large role. Among the causative factors which have been cited are surgical and obstetrical trauma, traumatic injury, malignancy, tuberculosis (it has been my observation that tuberculous patients are less prone to thrombosis), lung abscess, cardiac disease, ulcerative colitis, and appendicitis with abscess. Often no cause at all can be determined.

The pathological physiology of acute massive venous occlusion is that of a sudden and complete venous obstruction associated with intense vasospasm of the arterial tree, but dilatation and engorgement of the venous side. As can be seen in Figure 1, partial obstruction leads to slowing, sludge formation, and thrombosis. Complete occlusion, besides causing venous thrombosis, leads in time to arterial thrombosis, anoxia, tissue asphyxia and death, namely, gangrene. The swelling and edema in themselves play a part in the vicious circle leading to still further impairment, retention of metabolites and electrolytes, and ultimate complete physiologic degeneration of the part with systemic effects. Herein is laid the background not only for gangrene, which is of immediate concern, but also the deep-seated changes in cell permeability, fibrosis, low-grade anoxia, chronic induration, and, later, the brawny induration, eczemas, and ulcers seen in postphlebitic states.

The clinical course of the typical case, while presenting a clear-cut pattern, may nevertheless vary, since the processes described above may be halted at any stage.

6. DeBakey, M., and Ochsner, A.: Phlegmasia Cerulea Dolens and Gangrene Associated with Thrombophlebitis: Case Reports and Review of Literature, Surgery **26**:16-29 (July) 1949.

7. Haimovici, H.: Gangrene of the Extremities of Venous Origin: Review of the Literature with Case Reports, Circulation **1**:225-240 (Feb.) 1950.

Consequently one may see simply a phlegmasia alba dolens, a mild phlebothrombosis, a cerulea phlegmasia dolens, or gangrene, or any combination of the above. The process begins with a sudden onset of tingling, numbness, and weakness in an extremity, associated with severe pain and accompanied or followed rapidly by marked swelling and edema of the part. The latter is often so intense that the patient is firmly convinced that the leg will "burst." The swelling advances with great rapidity and may even involve the groin and at times the lower abdominal quadrant. Large quantities of plasma, blood, fluid, and electrolytes are lost to the general circulation by being trapped in the extremity. Because of this sudden trapping of the blood by blockage of its exit (the veins) while its entrance (the arteries) is open, the effect is that of a semi-elastic container being overfilled. This is demonstrated by the rapid advance of a wooden or rubber-hard swelling and increase in size of the extremity. The

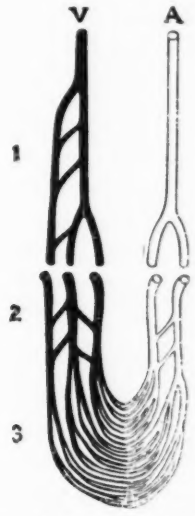


Fig. 1.—Diagram showing the anatomic findings of the blood vessels in an extremity affected by gangrene of venous origin: Occlusion of the whole venous tree (*V*) including both the deep and the superficial main trunks (1), the medium-sized veins (2), and the small branches (3). Patency of the whole arterial tree (*A*). (From Haimovici.[7])

edema may even defy pitting as the skin becomes more and more stretched. As this continues the metabolism of the part diminishes and the extremity becomes cool and even cold, with loss of sensation and function. A dusky, cyanotic, purplish hue develops early in foot, leg, and thigh, with a background of mottled red giving the skin an appearance of being marbleized. Petechiae and subepidermal hemorrhages give the leg and parts a blackish hue. The pedal and the femoral artery pulses may become diminished in volume to the point of complete loss, leading to gangrene and eventual loss of parts or an entire extremity. This gangrene usually comes on in four to eight days, is mostly of the moist type, and is generally superficial in degree. Hence, a conservative policy for its management is best in the early stages. This has led observers to make the diagnosis of arterial embolus in

many instances. It is worth noting, however, that arteriograms often display arterial patency despite diminished size and a spastic state. The diagnosis of acute massive venous occlusion depends upon an accurate history, as well as upon the recognition of the clinical sequence of events and the knowledge that such an entity exists.

As might be expected, acute massive venous occlusion is accompanied by variable degrees of shock, ranging from mild to severe, and at times leading to an irreversible stage and death.

Treatment should first be directed to combating the shock. This is followed immediately by measures designed to restore normal physiology as soon as possible. This may consist of fluid infusions, sedatives, antispasmodics, and transfusions of blood, plasma, or possibly blood substitutes. I believe that the restoration to normal physiology can be further accomplished by removing the abnormal block or occlusion, and then alleviating the secondary sequelae, such as vasospasm and a tendency to thrombosis and loss of tissue. In my opinion, immediate thrombectomy through the superficial femoral vein will relieve the obstruction. Paravertebral block relieves much of the vasospasm, and the use of anticoagulants will prevent clot propagation and halt recurrent thrombosis at the site of thrombus removal. Heparin is the ideal anticoagulant, as its administration may be halted temporarily to ensure that the paravertebral block is done with safety, minimizing the risk of retroperitoneal hemorrhage at this site. Some of these dangers have been well pointed out by Lilly and Lee.[8] Thereafter early exercise and early support to the extremity are urged and practiced.

REPORT OF CASES

CASE 1.—P. M., an automobile worker, aged 35, without a history of previous illnesses, was seen on July 1, 1941. He had had symptoms of a renal calculus with evidence of a partial right ureteral obstruction found by cystoscopy. One week later while visiting his physician he was seized with tingling, numbness, and severe pain in the right lower extremity, gradually becoming more acute during the next 24 hours. With these symptoms a large amount of edema and swelling of the member developed, associated with a peculiar bluish color of the skin. The left leg also had numbness and tingling. Upon entry to the hospital he complained also of precordial pain, without radiation, and dyspnea.

Physical examination revealed a man in severe pain and marked shock. The right lower extremity was tremendously swollen and was cyanotic with a reddish background. This mottling extended into the thigh with hard, non-pitting edema. The extremity was cold and clammy. The left extremity was also slightly swollen, cool, and mildly cyanotic. Blood pressure was 100/90 mm. Hg; pulse, 112; temperature, 98 F.; respiration, 25. There was some right lower quadrant abdominal tenderness. The right femoral pulse was absent. After treatment of shock he was taken to the operating room with a tentative diagnosis of femoral embolus. Under ether anesthesia the femoral pulse returned. An incision was made in the femoral triangle, and intense engorgement of the saphenous and femoral veins was found. The artery was small and spastic. The femoral vein was tremendously enlarged. When the abdomen was opened the iliac vein was found to be greatly distended, rubbery, and not compressible. The vena cava had the same consistency. Because of the circumstances and the poor state of the patient, thrombectomy was attempted through the saphenous vein. (NOTE: Were I to encounter such a situation today, experience would cause me to act more boldly and attempt large vessel aspiration.) The attempted thrombectomy was unsuccessful; paravertebral blocks and heparin were employed. In the left arm there developed some unexplained transitory paralysis, which disappeared in 48 hours. After operation, the patient became irrational, and partial anuria developed. Edema of the hips, sacrum, and back increased and finally reached the right axilla. Blood nonprotein

8. Lilly, G. D., and Lee, R. M.: Complications of Anticoagulant Therapy, Surgery **26**:957-969 (Dec.) 1949.

nitrogen was 186 mg. per 100 cc.; blood chlorides, 458 mg. per 100 cc. Nine days after admission to the hospital the right arm became swollen. Fluid with a urinary odor exuded from all incisions. Tests proved this was not urine. On the 13th day the right leg, although still swollen, was pale and warm. Pain in the right ankle was followed by a contracture of the right Achilles tendon. Gradually but slowly the patient improved and, on Aug. 28 was discharged from the hospital. When seen on Dec. 16, he had slight edema of the right foot, slight stiffness of the right ankle, and some contracture of the Achilles tendon. The leg and thigh showed no edema or swelling; the skin color and texture were normal. On March 6, 1942, the leg and thigh were small. The right ankle was still stiff, with moderate contracture of the Achilles tendon. The patient resumed his occupation as a mechanic. He died in 1948 of unrelated causes, as reported to me by his physician.

CASE 2.—Mrs. G. S., a woman of 65, was awaiting resection of the cecum for carcinoma. Upon returning to her bed from the bathroom she noted a sudden tightness in the left leg, followed in a few hours by rapidly increasing swelling and edema of the foot, leg, and thigh. This was associated with cyanosis of the part. The notations by the nurse on the hospital record stated, "Leg is reddish, blue, and edematous." Five hours later the leg and thigh were hard and firm to palpation. The peripheral pulses were intact, although the extremity was definitely cool to the touch. The left leg measured 3 in. (7.6 cm.) greater than the right in circumference. A diagnosis of femoral venous thrombosis was made, and the patient was prepared for operation. The erythrocyte count on admission was 2,800,000, with hemoglobin 5.5 gm. Under local anesthesia the femoral triangle was explored. The femoral vein was distended and dark in color. After careful opening of the superficial femoral vein, a large thrombus 6 in. (15 cm.) in length was aspirated from the distal segment, and several others 2 in. (5 cm.) in length were removed from the common femoral vein (Fig. 2). This was followed by a free flow of blood. The superficial femoral vein was ligated and divided at the profunda, which was patent. Paravertebral block was performed immediately. Despite moderate blood loss, the patient made an excellent postoperative recovery. There was steady decrease in size of the extremity. The postoperative therapy consisted of supportive and anticoagulant measures. Eleven days later a prophylactic superficial femoral vein ligation was carried out, followed three days later by resection of the large bowel, which was tolerated with no untoward results. The condition of both legs remained normal (Fig. 3). Death occurred two years later of carcinomatosis.

CASE 3.—L. M., a laborer of 48, was perfectly well until Jan. 3, 1947, when he was awakened by pain in the left foot, associated with swelling of the left ankle. He went to work at 8 a. m., but noted that the left leg was swollen and appeared to be warm. At this time there was no pain. By noon he noted swelling of the thigh and some discomfort on walking. Shortly, however, he noted intense "bursting" pain of the extremity. Immediate admission to the hospital was ordered. Results of physical examination were essentially negative, except for an amputated left arm and involvement of the left lower extremity. The left thigh, leg, and foot were markedly swollen, approximately one-third greater than the opposite extremity. The left leg was discolored, deeply cyanotic, and edematous, but not tender. It was cool to the touch. The dorsalis pedis pulse was present. The right leg had mild varices. A diagnosis of left femoroiliac venous occlusion was made. Under local anesthesia the femoral triangle was entered. There was marked engorgement of the superficial vessels. The femoral artery pulsated well. The femoral vein was three times normal size, with marked perivascular reaction. The femoral vein was opened, and a large amount of clot of jelly-like consistency was removed with forceps. A glass aspirator was then passed up to the iliac vein, and large amounts of clot and somewhat milky fluid were removed. Free bleeding ensued. Only a small amount of thrombus was obtained distally. The superficial femoral vein was then ligated and divided. Paravertebral block was performed in the operating room. Treatment with anticoagulants was started some hours later. The following day the thigh and leg were swollen and tense, but warmer and less cyanotic. Active motion of the extremity was encouraged. The left thigh measured 20½ in. (52 cm.), the right 18 in. (46 cm.). Steady improvement occurred, and in three days the calf decreased 2 in. in circumference (Fig. 4). The patient was discharged on the 13th day and returned to work 10 days later. On Jan. 30, 27 days after onset of illness, the thigh and leg were slightly tense but otherwise normal. He has continued to remain well.

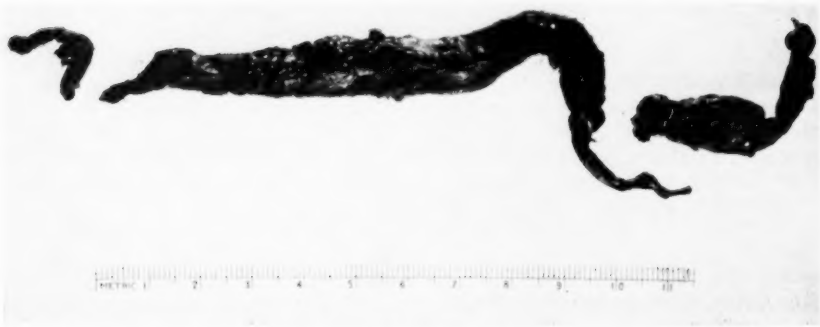


Fig. 2 (Case 2).—Thrombi removed from superficial and common femoral veins.

Fig. 3 (Case 2).—Fourteen days after thrombectomy. Note normal status of left leg. Right prophylactic femoral ligation was done three days before photograph was taken.

CASE 4.—O. K., a retired worker of 72, while preparing breakfast for his wife, was suddenly seized by numbness, tingling, weakness, and pain in the entire right lower extremity, rapidly followed by much swelling and symptoms of severe shock. On his entry to another hospital the pain was intense. The extremity was dusky and cyanotic and marbled in appearance (Fig. 5). The pedal pulses were absent but returned in approximately one hour after opiates had been administered freely. When seen a few hours later, after transfer to Harper Hospital, he had partially recovered from shock but was still in moderate pain. The cool and clammy extremity was markedly swollen from toes to groin, dusky and cyanotic, not tender to touch. The pedal pulses were present. The leucocyte count was 16,600; polymorphonuclears, 87%; red blood cells,

Fig. 4 (Case 3).—*A*, 12 days after left thrombectomy. Moderate swelling, excellent function. *B*, same as Fig. 4, rear view.

4,690,000; hemoglobin 12.9 gm. The urine contained 3+ albumin and casts. A diagnosis of acute venous iliac thrombosis was made. Under pentothal and ether anesthesia, the superficial femoral vein was exposed. It was large but soft, and showed perivascular reaction. The vein was opened, and a soft thrombus of jelly-like consistency was removed, a large amount of thrombus under apparent intraluminal pressure being expelled in the course of the operation. A glass aspirator was passed upward to the iliac vein, removing more soft clot. By catheter a laminated thrombus was finally removed (Fig. 6). Free bleeding ensued from the now patent vessel. A small amount of thrombus was then removed from the distal segment of the vein. The vessel was next ligated and divided. A blood transfusion (500 cc.) was given. Four hours after operation the blood

Fig. 5 (Case 4).—Before operation. Note difference in size and color of extremities.

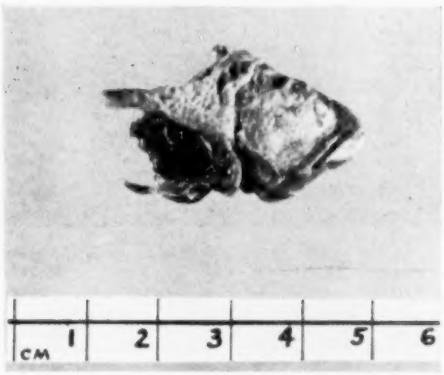


Fig. 6 (Case 4).—Laminated thrombus removed from iliac vein.

pressure was 100/50 mm. Hg, and there was distinct clinical improvement. The following day the extremity was warm and showed better color (Fig. 7*A*). Anticoagulants and benzazoline (priscoline®) were administered. The dorsalis pedis pulsated normally. Three days later the leg appeared much improved, with practically no swelling and only slight edema of the ankle (Fig. 7*B*). The patient left the hospital in approximately 10 days, and has remained well, with minimal residual effects.

CASE 5.—A. R., a 33-year-old veteran, was readmitted to the United States Veterans Administration Hospital, Dearborn, Mich., after previous resection of cervical lymph nodes for adenocarcinoma. He complained of lower back pain radiating to the flanks, testicles, and especially to the left thigh and leg. Shortly after his admission pain in the left thigh became more severe.

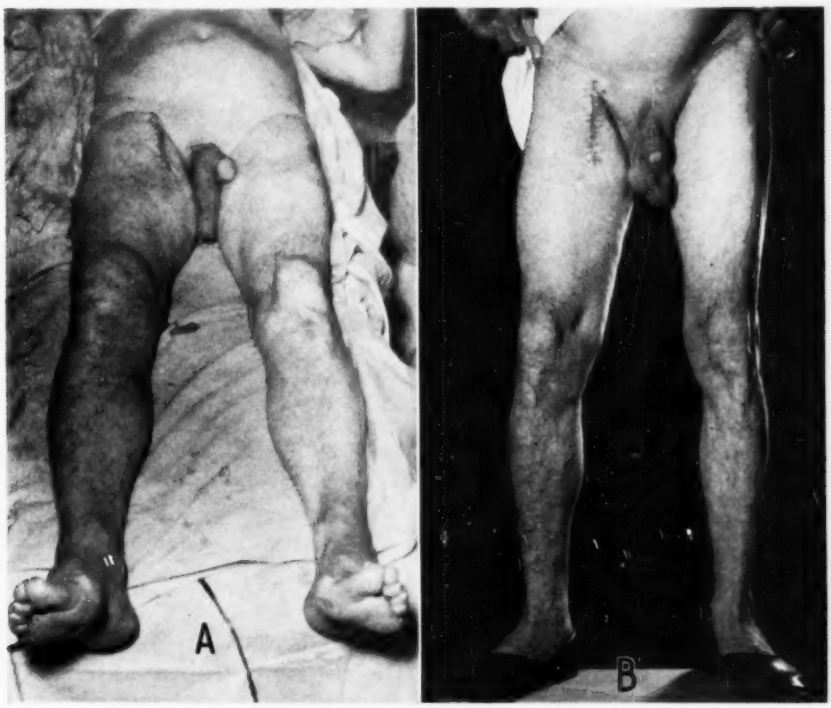


Fig. 7 (Case 4).—*A*, immediately after operation. Compare lighter hue of right extremity with that of Figure 5. *B*, seven days after operation. Note relatively little swelling and normal color.

He was seen by an attending surgeon who elicited the history that he had had mild pain in the left knee region with swelling, which (in two hours) extended into the calf and thigh. Pain was not severe. There was marked enlargement of the entire left lower extremity from toes to groin. The foot only was cold. Skin sensations and muscular functions were normal. The femoral pulse was absent. The swelling was of tense rubber-like hardness, and the whole extremity had a dusky, cyanotic hue. No pitting on pressure was elicited. Sympathetic block was performed; morphine and papaverine were given. Some diminution of swelling was apparent four hours later. Six hours thereafter I saw him in consultation and recommended thrombectomy. This was done by Dr. G. Wilson, resident surgeon, under spinal anesthesia. The femoral artery was extremely small and spastic, and only very feeble pulsations were noted. The tremendously engorged vein was opened and found to be filled with clot. The distal thrombus

was aspirated and free blood flow was obtained. Clots were next aspirated from the proximal part until free bleeding occurred. After patency of the profunda was determined, the superficial femoral vein was ligated and divided. There was definite improvement after operation (Fig. 8), and recovery was steady except for persistent leg pain, which was finally partially relieved by paravertebral block. Sympathectomy was attempted but was unsuccessful. The patient was discharged two months later (July, 1951). The left extremity had decreased in size, although the patient's general condition was not of the best. One month after discharge, he again reentered the hospital, and was now found to have marked edema of both lower extremities

Fig. 8 (Case 5).—Some swelling of thigh and leg, but marked decrease as compared to initial appearance.

and the abdominal wall. There was evidence of ascites and liver enlargement. He was mentally confused and at times irrational. Progress was steadily downhill, and 18 days after this entry he died, on Sept. 2, 1951. Autopsy revealed a primary carcinoma of the left kidney, of small size, with massive retroperitoneal extension and invasion of the right kidney. There were metastases to the liver and lungs. The left renal vein was filled with tumor growth, and the inferior vena cava was filled with neoplasm from the iliac veins to the entrances of the hepatic veins. The iliac veins were filled with a relatively soft thrombus. Since three and a half months

had elapsed since the acute massive venous occlusion, it seems evident that the original thrombosis in May had been a true vascular phenomenon. The course, following discharge in July, involved a gradual extension of the neoplasm into the vena cava with ultimate complete obstruction.

SUMMARY

Massive venous occlusion is better designated by the term acute massive venous occlusion, since the clinical picture is dependent upon the acuteness as well as the completeness of the thrombosis. It is neither a common nor a new entity, having been recognized as early as 1593 by Hildanus, although relatively few large series have been reported. Excellent reviews of this subject have been given by DeBakey and Ochsner[6] and Haimovici.[7] The condition may or may not result in gangrene. It is frequently fatal. Many etiologies have been described. The most common agents are surgical and obstetrical trauma, infection, malignancy, and traumatic injury. It is noteworthy, however, that frequently no evident causative factor is demonstrated. In my series, concurrent carcinoma, was present in two cases, one followed cystoscopy, and in two no known antecedent cause was evident. The right leg was involved in two instances and the left in three. The clinical course is usually strikingly similar. The onset consists of tingling and numbness in the extremity, followed rapidly by pain which is usually severe. Extensive swelling with a hard rubbery consistency ensues. The part affected becomes cyanotic and, at times, has a deep purple hue. The extremity is cool or cold to the touch. Variable degrees of shock, usually severe, are present.

The pathological physiology of acute massive venous occlusion is that of complete stoppage to the venous return from the affected extremity, and a back-pressure effect which prevents arterial blood from entering the arteries even though these are patent, as has been shown by arteriography.[2] Concomitant vasospasm is intense.

The diagnosis is based upon the recognition of the succession of clinical events. The speed of onset and the location of the thrombus in the larger vessels are the chief factors in distinguishing acute massive venous occlusion from the ordinary phlegmasia alba dolens. One may postulate that a silent thrombus might suddenly be detached and carried to a strategic area (femoral or iliac), where it becomes wedged either because of size or position to produce the syndrome. On the other hand, a thrombus may be formed in situ within a larger vessel. With increased growth or dislodgment, sudden occlusion of the lumen might also produce this picture. The acute disturbance of the local and general physiology necessitates prompt and immediate action. With this in mind, I advocate immediate thrombectomy with the addition of paravertebral block and anticoagulant therapy. Highly satisfactory results without gangrene formation or other serious sequelae were obtained whenever thrombectomy had been performed in my series. Veal,[9] on the other hand, has recently reported excellent results in similar cases by the institution of elevation of the extremity and forced exercise. The threat of fatal embolism, however, would seem to substantiate the rationale of prompt and effective thrombectomy.

9. Veal, J. R.; Dugan, T. J.; Jamison, W. L., and Bauersfeld, R. S.: Acute Massive Venous Occlusion of the Lower Extremities, Surgery **29**:355-364 (March) 1951.

CONCLUSIONS

1. This disease entity should be termed acute massive venous occlusion, since the rapidity and completeness of the occlusion are the chief factors in producing the clinical picture.

2. It is conceivable that dislodgment of a preformed thrombus elsewhere in the extremity or thrombus formation in situ within the femoroiliac area can produce acute massive venous occlusion.

3. Acute massive venous occlusion is a dire emergency which necessitates prompt recognition and equally prompt treatment.

4. In this experience immediate thrombectomy, followed by the use of paravertebral block and anticoagulants to prevent recurrence, has given excellent results.

5. Early and complete thrombectomy may be the decisive factor in the prevention of gangrene and localized tissue damage.

LATE RESULTS OF INFERIOR VENA CAVAL LIGATIONS

RICHARD ZOLLINGER, M.D.
AND
WELLS H. TEACHNOR, M.D.
COLUMBUS, OHIO

LIGATION of the inferior vena cava is a logical procedure for a limited group of patients whose lives are threatened from the danger of pulmonary embolism. The chief drawback of this measure has been fear of disabling complications resulting from the procedure itself. A careful follow-up study on 20 such patients will be presented in order that the after-effects of such ligations may be carefully considered and evaluated.

Kocher performed the first vena caval ligation of record in 1883, and Billroth attempted one in 1885. However, these were done because of operative trauma and were followed by fatal outcomes.[1] The first successful ligation was accomplished by Bottini. Cliffton and Neel, in their review of the literature, found that 136 vena caval ligations had been reported up to November, 1949.[2]

The indications for ligation of the inferior vena cava have fallen into four main groups: (1) operative trauma; (2) an active form of therapy for the sequelae of bilateral chronic thrombophlebitis of the lower extremities; (3) a last-stage procedure to prevent a possible fatal pulmonary embolus or a recurrent pulmonary embolus, and (4) a prophylactic measure done at the time of abdominal exploration for some other primary condition.

The dictum for the surgical ligation of veins in the prevention of embolism is ligation above the thrombosis and below a large collateral vessel.[3] It is generally believed that the ligation of the superficial femoral veins offers the desired result, without serious impairment to the collateral circulation. However, if the thrombotic process has extended to any point above the superficial femoral vein, the vena cava may be ligated with little operative risk and with a maximum of security against embolism. The surgical approach is generally transperitoneal or retroperitoneal and is not a technically difficult procedure. The collateral circulation has been sufficient immediately after surgery, but longer periods of postoperative observation will be necessary before final conclusions can be reached.

From the Department of Surgery, Ohio State University, and the Surgical Service, Mount Carmel Hospital.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Nov. 30, 1951.

1. Pfaff, O. G.: Ligation of Vena Cava, Am. J. Obst. & Gynec. **11**:660-663, 1926.

2. Cliffton, E. E., and Neel, J. C.: Ligation of the Vena Cava in Extending Thrombophlebitis, Arch. Surg. **59**:1122-34, 1949.

3. O'Neil, E. E.: Ligation of the Inferior Vena Cava in the Prevention and Treatment of Pulmonary Embolism, New England J. Med. **232**:641-645, 1945.

CLINICAL OBSERVATIONS

We wish to present follow-up observations on 20 patients on whom vena caval ligations have been done in the past 5 years. The ages for the entire group ranged from 31 to 76 years, with an average of 53 years. There was no operative mortality, and 13 patients are still living and have been followed for an average of 35 months. There are seven patients who are deceased; these were followed for an average of 15 months. Of these patients six died of carcinomatosis and one of coronary heart disease. In other words, in the latter cases the primary surgical conditions eventually resulted in fatalities, and there was no relationship of the latter to the caval ligation.

The study was comprised of careful follow-up histories and physical examinations. We were interested in the following findings: edema, pain, ulcers, dermatitis, cellulitis, recurrent thrombophlebitis, varicosities, recurrent emboli, effect on locomotion, patient's economic status, and any miscellaneous unusual symptoms that could not be classified under any of the previously mentioned topics.

Eleven of our patients had transperitoneal caval ligations as a prophylactic procedure at the time of exploration for some primary condition. In all but two of these cases there was no evidence of a phlebitic process of the veins of the extremities or

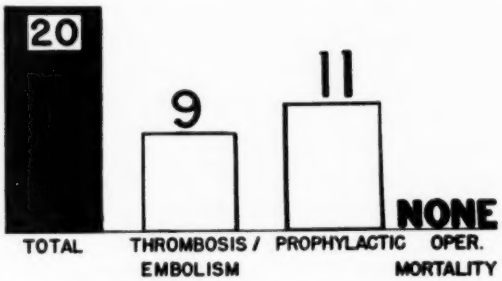


Chart 1.—Indication for ligation of inferior vena cava in this series.

of the pelvis, at the time of surgery. Five patients had advanced carcinomatosis, and their veins were ligated because of their age, primary diagnosis, and danger of a postoperative phlebitis with embolism. The remaining six ligations were done because of the presence of large benign ovarian tumors or other pelvic pathology. Two patients also had associated chronic iliofemoral thrombophlebitis.

The remaining nine patients had vena caval ligations performed as primary procedures for venous pathology alone or for reasons associated with its complications. Indications for vena caval ligation in this group were the usual ones reported; iliofemoral thrombophlebitis or phlebothrombosis, bilateral or unilateral, with and without pulmonary emboli. Chart 1 summarizes these data.

A more detailed analysis of the various subjective and objective findings is next in order.

Edema.—Detailed studies of the vascular responses in humans after ligation of the vena cava have been reported by Ray and Burch, and Shea and Robertson.[4]

4. Ray, C. T., and Burch, G.: Vascular Responses in Man to Ligation of the Inferior Vena Cava, Arch. Int. Med. **80**:586-601, 1947. Shea, P. C., Jr., and Robertson, R. L.: Late Sequelae of Inferior Vena Cava Ligation, Surg., Gynec. & Obst. **93**:153-158, 1951.

There is general agreement that there is increased venous pressure in the lower extremities in most of these patients. There is also agreement that no relationship exists between the venous pressure and the degree of edema.

Some insight into understanding the postoperative edema following vena caval ligations can be obtained from the following case summary.

A 57-year-old woman underwent surgery on April 11, 1947, at which time a papillary carcinoma of the ovary with peritoneal metastasis was found. A bilateral oophorectomy, with excision of scattered metastatic areas, was done. The vena cava was ligated at this time as a prophylactic measure. The patient was discharged on the 20th postoperative day and was ambulatory until her death, some seven months later. During this time she had no symptoms referable to her legs except minimal swelling of the left lower leg and ankle. Venograms taken a week prior to her death showed patency of the superficial and deep veins of the left leg. Contrast material was visualized in the deep circulation; it then passed upward through the femoral vein into the pelvis and disappeared in the vicinity of the sacrum. Some superficial veins were visualized in the region of the left acetabulum and were superimposed over the left wing of the sacrum. The right extremity showed contrast material passing upward in the deep circulation into the region of the femoral triangle, where it entered the superficial circulation and was distributed over the

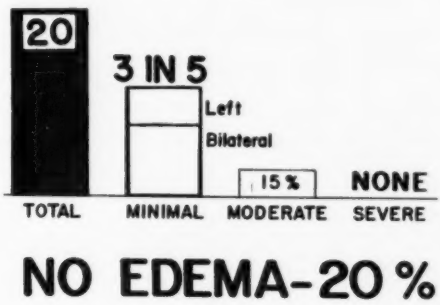


Chart 2.—Incidence of leg edema following inferior vena caval ligation.

abdominal surface. From the venograms one might assume that the circulation was more adequate in the left lower extremity, but the objective and subjective findings contradict this. These findings tend to substantiate the impression that the edema is more dependent on the lymphatics than on the collateral venous circulation.

The autopsy showed the vena cava to contain an organized grayish-yellow thrombus. The iliac vessels could not be followed to their termination because of a mass of neoplastic tissue. However, dissection carried out on the sides of the vertebral column showed enormous ascending lumbar venous trunks connecting with the common iliac veins.

Our patients can be further classified according to the amount of their edema. The amount of swelling was variable. If the use of elastic bandages is a criteria indicating the amount of objective and subjective symptoms from edema, we find that seven patients required bandages while on their feet. The patients with no edema, or with minimal amounts, who required no compression bandages to their extremities have been followed for an average of 45 months since their original surgery, as compared to 29 months for those who required bandaging, either constantly, while at work, or intermittently. This is a difference of approximately 15 months. Perhaps, if given the extra time, the latter group too will acquire the necessary collaterals so that external support will not be necessary (Chart 2).

Pain.—Pain was not a major complaint in any of the patients. Actually four patients, who had causalgia from chronic thrombophlebitis, had relief after ligation of the inferior vena cava. One patient, who had had a bilateral iliofemoral thrombophlebitis associated with pregnancy, has had intermittent attacks of pain from superficial and deep phlebitis. This was noticed in the calves and occasionally in the thighs, legs, and low back. These attacks, however, have become less noticeable and have not been present for the past year. A second patient has had intermittent attacks of pain in the extremities, which appear to be partially caused by a toxic arthritis that developed after a cholecystectomy. In general, it can be said that pain was neither an objective nor a subjective finding in any of the cases except these two, and it was found only intermittently in these.

Ulcers, Dermatitis, Cellulitis and Recurrent Thrombophlebitis.—These findings are directly related to edema and the susceptibility of edematous tissue to infection. The absence of these changes in the majority of our patients substantiates our statement that edema in the postoperative period was minimal.

Ulcers of the lower extremities were noted in two patients and as a postoperative development in only one. The latter is a 50-year-old man whose inferior vena cava was ligated for a postoperative left iliofemoral phlebothrombosis, associated with a pulmonary embolism. Prior to the past year, small ulcerations had developed on the lower extremities as a result of trauma suffered while he was doing manual labor. These healed in four to six weeks with compression bandages. In the past year he has been wearing leather leggings for protection, with no recurrence of ulcers.

Dermatitis did not develop after vein ligation in any of our patients. However, it was present on both legs in one patient prior to surgery. This 51-year-old man gave a 20 year history of chronic thrombophlebitis of the lower extremities. He had had saphenous vein ligations and injections for secondary varicosities of the saphenous systems. Pulmonary emboli had occurred several times in the years prior to our therapy. The dermatitis had been present for many years. Ligation has not improved the dermatitis, nor has it accentuated it.

Recurrent thrombophlebitis, superficial and deep, was noted only in the 31-year-old pregnant woman.

Varicosities.—In three patients varicosities developed after inferior vena cava ligation. These are minimal and thus far have not been of enough consequence to demand any special form of therapy. Two other patients had secondary varicosities of the saphenous systems prior to caval ligation.

Apparently, therefore, an efficient deep collateral venous and lymphatic circulation has developed in these persons. However, it is important to stress the use of compression bandages for a time following venous ligation. These support the superficial veins until a deeper collateral circulation develops.

Effect on Locomotion and Economic Status.—Some of the patients complain of heaviness in their legs after strenuous exercise or long hours of standing. This complaint seems proportional in severity to the amount of dependent edema.

The five patients with advanced carcinomatosis did not return to their original labors because of their cancers, but four became ambulatory. Six patients who had prophylactic ligations at the time of surgery for ovarian tumors or other pelvic pathology became ambulatory and returned to their previous tasks. Of the nine

patients who had inferior vena cava ligations for venous pathology alone or for reasons associated with its complications, six returned to their previous tasks. Of the nine patients who had inferior vena cava ligations for venous pathology alone or for reasons associated with its complications, six returned to their previous economic pursuits and have noticed no change in their abilities. The remaining three cannot be justly evaluated because of their primary surgery, which has necessitated a postoperative course consisting mainly of bed rest.

In summarizing, we can say that 16 of our 20 patients became ambulatory and 12 of these returned to a gainful occupation. Five of our series died of carcinomatosis; one has not recovered from an osteotomy; in one crippling toxic arthritis developed after a cholecystectomy and colostomy, and one died as the result of coronary heart disease. We can say that all the patients for whom recovery was expected returned to their normal duties (Chart 3).

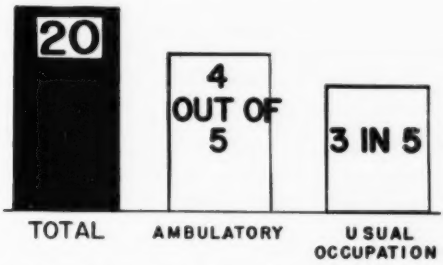


Chart 3.—Effect of inferior vena cava ligation on locomotion and economic status.

Summation of Complications of Ligation of Inferior Vena Cava

Late Sequelae	No. of Cases
Varicosities	5
Ulcers (healed)	2
Pain (intermittent)	2
Dermatitis	0
Cellulitis	0

Miscellaneous.—Three patients have noticed that the wearing of any tight clothing about the chest or abdomen causes increased edema and fatigue of the lower extremities. In these persons the superficial venous circulation has become a main collateral.

In the table are listed the late sequelae which developed in this series.

SUMMARY

Twenty cases of ligations of the inferior vena cava have been presented. There was no operative mortality.

Our indications for these ligations have been three: (1) a last-stage procedure to prevent a possible fatal pulmonary embolism or a recurrent embolus; (2) an active form of therapy for the sequela of bilateral, chronic thrombophlebitis of the lower extremities; (3) a prophylactic measure for patients with advanced carcinomatosis or for older individuals with large intra-abdominal tumors.

An analysis of the postoperative study of all these patients has been prepared.

CONCLUSIONS

The late sequelae of vena cava ligation are variable and probably depend on the extent of venous and lymphatic pathology. However, they are consistent with the economic rehabilitation of the patient.

DISCUSSION

DR. HENRY SWAN, Denver: These two papers are extremely timely, since the problem of venous thrombosis is constantly with us, and I think that Dr. Osius has brought out an extremely important point, which I want merely to emphasize. That is the tremendous importance of the reflex action of the arterial tree in venous thrombosis in a limb, particularly the lower extremity. Now, this is quite different from the effects which occur when major ligation of the veins of the lower leg is done.

Last year before this Society Dr. Morfit and I reported three cases in which rather radical surgery was done for neoplasms; the entire venous tree was resected, including the common femoral vein at its bifurcation into the deep and the superficial, together with the saphenous. So here, then, were three patients we had helped, in spite of the fact that presumably most of the venous system had been completely excised. Yet these persons do not show any difficulty in arterial flow as does occur following massive thrombotic occlusion. It certainly is important to remember this fact, and I should like to urge the use of early and rapid sympathectomy, as Dr. Osius has mentioned.

DR. EUGENE A. OSIUS, Detroit: I did not get up to the platform in time to compliment Dr. Zollinger on his splendid presentation of inferior vena cava ligation. It was a paper carefully worked out and beautifully presented, and I wish to say that in our experience with 12 cases our results have been identical and our indications have been the same, except that we have not used the procedure prophylactically. We feel that inferior vena cava ligation has a distinct place in the management of deep thrombophlebitis and its various complications, but we are just as firmly convinced that the procedure should not be abused and carried out without definite indications. The fact that it can be done safely is no argument for its use without proper indication. Dr. Zollinger's cases were carefully and thoroughly studied before operation was performed.

HEPATIC, SPLENIC, AND LEFT GASTRIC ARTERIAL LIGATIONS IN ADVANCED PORTAL CIRRHOSIS

JACOB K. BERMAN, M.D.
AND
JAMES E. HULL, M.
INDIANAPOLIS

IN MARCH, 1947, one of us (J. K. B.) began investigating the effects of hepatic and splenic artery ligations on portal pressures in normal and in portal hypertensive dogs. Summaries of this work have been presented,[1] and a report of our first case [2] has been published.

This paper is an account of our first 12 cases with advanced portal cirrhosis of the liver treated by hepatic, splenic, and left gastric arterial ligations.

INDICATIONS AND CONTRAINDICATIONS

These patients were operated upon because they were cirrhotics who did not respond to medical management, including use of cation-anion resins, and who, in addition, had symptoms and signs which are known to indicate a poor prognosis if allowed to persist or progress. The symptoms and signs in the order of their gravity were (1) rapid regression in the size of the liver; (2) bleeding varices or bleeding from the gastrointestinal tract; (3) persistent vomiting or diarrhea or both; (4) ascites; (5) somnolence and lethargy; (6) uncontrollable edema; (7) persistent jaundice, and (8) associated hypersplenism. It has been shown by members of our gastroenterology department [3] that when the liver begins to regress rapidly in size, death usually occurs within two and one-half months. The over-all duration of the disease in these patients is approximately four years. Following

This study was aided by a grant from the Charles J. Wolf Foundation for Medical Research.

From the Department of Surgery of the Indianapolis General Hospital and the Indiana University Medical Center.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Nov. 30, 1951.

1. (*a*) Berman, J. K.; Koenig, H., and Saint, W. K.: Ligation of the Hepatic and Splenic Arteries in the Treatment of Portal Hypertension, Indiana Univ. Quart. Bull. **12**:99, 1950. (*b*) Berman, J. K., in discussion on Grindlay, J. H.; Mann, F. C., and Bollman, J. L.: Effect of Occlusion of the Arterial Blood Supply to the Normal Liver: An Experimental Study, A. M. A. Arch. Surg. **62**:806, 1951.

2. (*a*) Berman, J. K.; Muller, L. P.; Fisch, C., and Martz, W.: Ligation of the Hepatic and Splenic Arteries in a Patient with Atrophic Cirrhosis of the Liver, A. M. A. Arch. Surg. **63**:623, 1951. (*b*) Berman, J. K.; Koenig, and Muller, L.: Ligation of the Hepatic and Splenic Arteries in the Treatment of Portal Hypertension: Ligation in Atrophic Cirrhosis of the Liver, A. M. A. Arch. Surg. **63**:379, 1951.

3. Moser, R. H.; Rosenak, B. D.; Pickett, R. D., and McIntire, C. R.: The Prognosis of Portal Cirrhosis: An Analysis of 62 Cases, Gastroenterology **18**:86, 1951.

a first hemorrhage from varices the average duration of life is 18 months; more than half of those who survive will bleed again, and their survival time will be about 13 months; of the latter group, one-fourth will have a third hemorrhage and their survival time will be about 4 months. Persistent ascites is a continuous plasmapheresis and is therefore extremely serious, indicating far-advanced hepatic decompensation. In 68% of the cirrhotic patients with ascites the duration of life is approximately 12 months, and only 17% survive 24 months.[4]

None of our patients had other forms of cirrhosis. However, the pathological distinctions between various types are not entirely clear, and it is therefore important that we list the different varieties so that we may properly evaluate the operation when used in cirrhosis other than portal. The more clearly defined cirrhoses are the following: 1. Fatty cirrhosis, which may be a forerunner of portal. 2. Obstructive biliary cirrhosis. 3. Toxic or infectious cirrhosis. This may not be a distinct entity but there is more necrosis than is seen in portal cirrhosis. Some observers believe it to be one form of atrophic or portal cirrhosis. 4. Syphilitic cirrhosis of the diffuse variety, or the "hepar lobatum" type. Two of our patients (I. B. and E. B.) had syphilis, but their cirrhosis was portal. 5. Capsular pseudocirrhosis. This often accompanies the polyserositis of tuberculosis or constrictive pericarditis with effusions into the serous cavities. Patients with advanced portal cirrhosis and ascites usually show great capsular thickening of the liver, spleen, and even the serosa of the gastrointestinal tract. 6. Central, cardiac, or passive hyperemic cirrhosis. One of our patients (H. O.) came to the hospital in cardiac failure; surgery was deferred for three months until the heart seemed to be in full compensation. 7. Hypertrophic biliary cirrhosis. 8. Portal cirrhosis associated with hemochromatosis. One of our patients (C. T.) showed hemochromatosis of the liver, lymph nodes, and spleen, but the cirrhosis was typically portal in distribution.

From a study of the 12 cases in which we have done ligations, we have learned that there are at least three definite contraindications to the operation: 1. The operation should not be done on patients who are actively bleeding from varices unless performed within the first 24 hours of bleeding. Although many observers have reported the successful control of bleeding varices by transesophageal ligation, esophageal stripping, resection of the lower esophagus and cardia, and other types of surgery, this has not been our experience unless done early—that is, within the first 48 hours. It is our opinion that in a majority of instances it would be safer to use the Patton-Johnston or Sengstaken-Blakemore tube[5] supplemented by liberal blood transfusion, large doses of vitamin K, and possibly the reverse Trendelenburg position, to decrease the pressure in the varices. Surgery is extremely hazardous after the entire blood volume has been replaced two or three times, even though the hematocrit value, plasma proteins, and blood volume appear to be within normal limits. Two of our three postoperative deaths have been those of patients with actively bleeding varices. One of these (C. C.) had been bleeding for three days, and the hemorrhage could not be controlled by pressure or any other measure. In desperation, operation was performed. This consisted of intraesophageal ligation

4. Ratnoff, O. D., and Patek, A. J., Jr.: The Natural History of Laennec's Cirrhosis of the Liver: An Analysis of 386 Cases, Medicine **21**:207, 1942.

5. Patton, T. B., and Johnston, G. G.: A Method for Control of Bleeding from Esophageal Varices, Arch. Surg. **59**:502, 1949. Sengstaken, R. W., and Blakemore, A. H.: Balloon Tamponage for the Control of Hemorrhage from Esophageal Varices, Ann. Surg. **131**:781, 1950.

of the bleeding varices and then ligation of the left gastric, the hepatic, and the splenic arteries. The patient stood the procedure poorly although blood transfusion was continued during the entire operation. However, there was a serious deficit in circulating blood volume, and it was impossible to get more blood because donors were not available. This patient died of shock and hepatic insufficiency due to blood loss. His failure to respond to the transfusions which were given was due to the persistent anemic anoxemia which had existed for a period of three days, producing irreversible changes in the damaged and ischemic liver cells. At autopsy, some free blood was found in the peritoneal cavity but no active bleeding site could be identified; however, the stomach was entirely filled with blood. Another patient (E. B.) was operated upon during active bleeding from varices. She, also, continued to bleed postoperatively. It seemed as though the more transfusions she received the more she bled. Perhaps she was one of those persons who have an adverse response to transfusions due to incompatibilities producing a bleeding tendency,[6] or the delicately balanced dynamic clotting mechanism may have become exhausted after the "alarm" and "defense" reactions were over. In such circumstances, antithrombin and heparin are present in excessive amounts. After the anticlotting factors have become predominant for a while, they are difficult to control even with the use of protamine, plasma, or whole blood.[7] From these experiences we believe that every effort should be made to control hemorrhage before surgery is instituted, and that if it is not controlled within 24 hours operation is mandatory before irreversible changes occur.

2. Persistent severe jaundice is a contraindication to surgery. This is usually associated with a large liver, indicating much venous stasis without shunts in operation and a great admixture of arterial blood in the liver. None of our patients were deeply jaundiced at the time of surgery, and in only one (I. B.) was the serum bilirubin level over 3 mg. per 100 cc. The few patients we have observed with persistent severe jaundice have died with hemorrhage or hepatic insufficiency within a relatively few weeks.

3. So far as we are able to judge from this group, there is only one other contraindication, and that is severe hypertension. This is illustrated by one of our patients (M. N.) who, in addition to cirrhosis of the liver and ascites, had hypertension with myocardial damage. This is a rare combination, and, as we have previously stated,[1c] is probably due to the fact that the crippled liver cannot produce the renin substrate (hypertensinogen), an alpha$_2$-globulin fraction of the plasma, which combines with the kidney enzyme renin to produce the vasopressor polypeptide angiotonin (hypertensin). Liver function tests on this patient were within normal limits. This would lend credence to the prevalent hypothesis that such a liver can produce sufficient substrate to combine with renin and elevate the blood pressure to the level which this woman had (systolic 230, diastolic 110). In cirrhotics with hypertension we must conclude that sufficient oxygen reaches the ischemic liver cells to produce enough angiotonin to maintain the elevated blood pressure. This is possible because of the ratio of pressures between the hepatic arterial and portal venous components. Normally the hepatic arterial pressure is

6. Whitby, L. E. H., and Britton, C. J. C.: Disorders of the Blood, Ed. 5, Philadelphia, The Blakiston Company, 1946.

7. DeTakats, G.: Personal communication to the authors.

120 mm. of mercury, and the portal venous pressure is 8 to 12 mm. of mercury, a ratio of about 10 to 1. In most cirrhotics the portal pressure is doubled, but the arterial pressure remains the same. Therefore the ratio becomes greatly reduced, amounting to about 5 to 1. Livers with such moieties of circulation are better able to withstand the sudden decrease of arterial pressure after ligation, although there is a temporary insufficiency of arterial blood, as manifested clinically by what we have termed "hepatic crisis." In patients with hypertension the ratio of pressures is again about 10 to 1 but on a much higher level. In our patient the portal pressure was 26 mm. of mercury and the systolic blood pressure was 230 mm. of mercury. The cirrhotic liver cells in such conditions obtain their oxygen through excessive arterial pressure, which they demand to remain viable. They apparently cannot withstand the sudden drop to near zero pressure after hepatic arterial ligation, and therefore the "hepatic crisis" becomes insurmountable. Conceivably, if the liver with such moieties could survive long enough for collaterals to form, it would benefit more from hepatic arterial ligation than would the cirrhotic liver in normotensive patients. The sequence may be compared to the anuria which follows prolonged hypotension in patients with ischemic kidneys and high blood pressure. Indeed, the anuria in hepatorenal syndrome following hepatic-splenic arterial ligation may be due to the fall in blood pressure which usually occurs in this crisis. Liver cells seem to remain viable long enough for collaterals to form if they have become acclimated to the ratio of pressures which usually occur in cirrhotics who are normotensive. Perhaps if we could lower the systemic blood pressure gradually so that vascular compensation would occur prior to surgery, the operation could be successfully employed. This patient's death two days postoperatively was probably due to hepatic and renal insufficiency, because she became anuric 48 hours after surgery. Postmortem examination disclosed the following significant findings: portal cirrhosis with multiple small infarcts in the liver, atelectasis of both lower lobes, and marked coronary atherosclerosis.

Poor liver function, as determined by the various laboratory tests, is not in itself a contraindication. In fact, at present, the only deterrents to the procedure other than acute intercurrent infection are (1) active persistent hemorrhage, (2) progressive jaundice, (3) severe hypertension in the presence of cirrhosis of the liver even though the liver function studies are within normal limits, and (4) cardiac decompensation.

PREOPERATIVE PREPARATION, TECHNIQUE OF OPERATION, AND POSTOPERATIVE CARE

Preoperative Preparation.—Advanced cirrhotics are prepared for surgery using the same standards that are employed for any other type of operation; however, there are certain special requirements. Blood volume must be restored. This is especially true of serum albumin, which is usually greatly depleted. Since there is also an associated severe anemia in most cases, repeated blood transfusions are indicated. Penicillin and streptomycin are used for two reasons: as a prophylaxis against postoperative pulmonary and wound infections and, more important, as a deterrent influence on the growth of indigenous liver bacteria. These organisms are known to play an important role in the hepatic necrosis which follows hepatic artery ligation in dogs, as first demonstrated by Markowitz and co-workers.[8] Vitamin

8. Markowitz, J.; Rappaport, A., and Scott, A. C.: Prevention of Liver Necrosis Following Ligation of Hepatic Artery, Proc. Soc. Exper. Biol. & Med. **70**:305, 1949.

K in large doses (60 mg. a day) is indicated because the prothrombin time is usually much prolonged, although in very late cirrhosis with extensive liver damage the drug may be ineffective. We may summarize the preoperative preparation of the patient with cirrhosis of the liver as follows:

1. Nourish the remaining liver cells with their necessary requirements, viz.: protein, glucose, vitamin K, oxygen.

2. Protect the liver cell against bacterial growth with antibiotics.

3. Supply the body with the products of liver synthesis which the crippled organ has been unable to produce viz.: blood cells, blood proteins, iron, vitamins, especially B, C, and K.

4. Spare the liver by restricting fats and sodium.

5. Avoid the use of drugs that cannot be properly detoxified. We have noted that patients with cirrhosis of the liver tolerate barbiturates poorly. Dogs with passive hyperemic cirrhosis may die if pentobarbital or any other barbiturate anesthesia is used.

6. Among the secondary effects of cirrhosis are those which affect the kidney. They are incompletely understood and often referred to as "cirrhotic nephrosis" to indicate tubular inability to excrete salt. Therefore the diet should be very low in sodium (about 1.5 gm. a day).

After about one week of preparation, the patient's condition is usually about as good as we can expect, and surgery may be undertaken.

Technique of Operation.—The operation is done through a longitudinal or transverse incision, as may be preferred by the operator. We have used the longitudinal incision in the linear type patients and have found this to be much more satisfactory than the transverse incision because one does not cut across the many collateral vessels which are part of the "caput medusae." We have employed the transverse incision in three of our patients who were of the lateral type.

The ascitic fluid is aspirated and measured, then the portal pressure is recorded with a water manometer. We used sodium citrate solution and allowed for the distance between the level of the manometer and that of the abdominal aorta. In one of our patients we measured the pressure in the splenic vein; in the others, we used a large omental vein. Measurement of portal pressure is more or less relative, and since we recorded the pressure in the same vein before and after ligation we feel that the results are informative.

The hepatic artery is felt by palpation through the epiploic foramen, and the hepatogastric ligament is divided. The hepatic artery is then identified and exposed by sharp and blunt dissection and tied as close to the celiac axis as possible (Fig. 1). If difficulty is encountered owing to edema, the hepatic artery may be traced back beyond the gastroduodenal branch by placing the finger in the epiploic foramen. Usually there are many lymph nodes around the celiac axis, and small pancreatic branches make the dissection tedious. We have used a triple ligation technique with 0 silk in seven patients, and in five we divided the artery between double ligatures. We do not feel, however, that this is necessary, because in both the experimental animal and the human we have not found a recanalization of the hepatic artery.

The splenic artery frequently can be isolated through the incision in the hepatogastric ligament, because it dips toward the right as it comes off the celiac axis

and then toward the left. The left gastric artery is also easily identified in the linear type patient and should be tied as close to the celiac axis as possible (Fig. 2). In the lateral type person and often in the linear type, it will be found that the splenic and the left gastric arteries are more accessible through an incision in the gastrocolic ligament, and therefore we have used two incisions in some of our obese patients. With the stomach mobilized and lifted upward, the vessels of the celiac axis are easily accessible, although some variations in their number or origin may be encountered (Fig. 3).

The more important abnormalities are as follows: The celiac artery may be absent, its branches arising separately from the aorta or some other source. Sometimes it gives off only two branches, usually the left gastric and splenic, and occa-

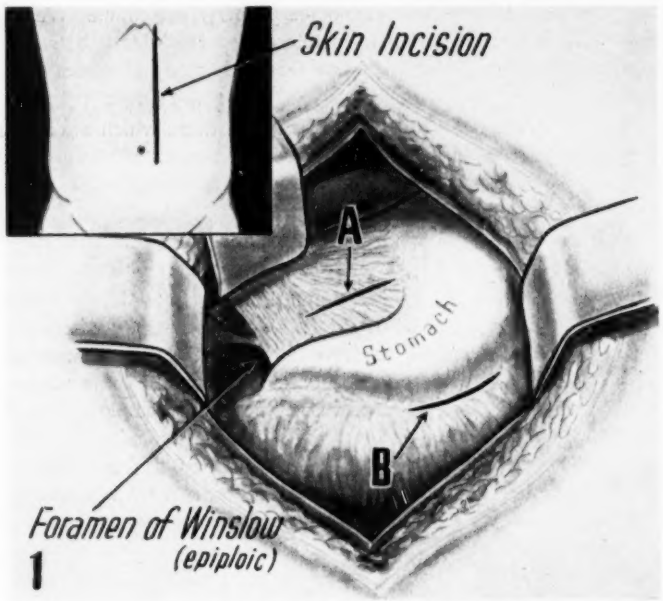


Fig. 1.—Technique of ligation of hepatic, splenic, and left gastric arteries in portal cirrhosis of liver. Left paramedian incision avoids cutting across abdominal collaterals. *A*, incision in hepatogastric ligament through which all three branches of celiac axis usually can be isolated. *B*, incision in gastrocolic ligament is used in obese patients for exposure of splenic and left gastric arteries.

sionally it gives four, the additional branch being either a second left gastric or a separate gastroduodenal artery. The hepatic artery also has many variations. It may spring directly from the aorta or superior mesenteric artery, and in 12% of patients there is an accessory hepatic artery that may originate either from the left gastric, superior mesenteric, renal, or inferior mesenteric artery or from the aorta. An accessory hepatic artery was encountered in one patient (C. T.). The left gastric artery is sometimes double. It may spring directly from the aorta, and it may give off the left hepatic or an accessory hepatic artery. The splenic artery may arise from the middle colic, from the left hepatic, or from the superior or the inferior mesenteric artery.

After the vessels have been ligated, a specimen of the liver is taken for biopsy and the portal pressures are again recorded for comparison. During the procedure, systemic blood pressures are read at frequent intervals, particularly at the time of ligation of important vessels and at 15 minute intervals thereafter. At no time have

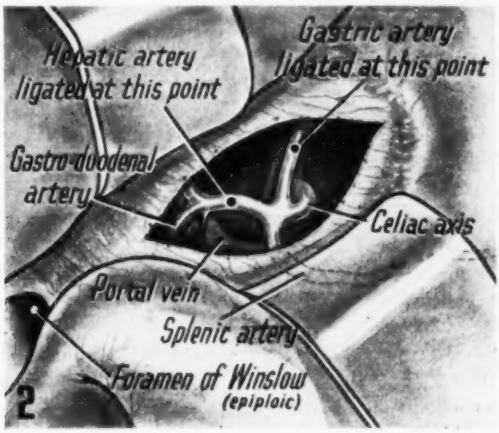


Fig. 2.—Sites of ligation of hepatic, splenic, and left gastric arteries.

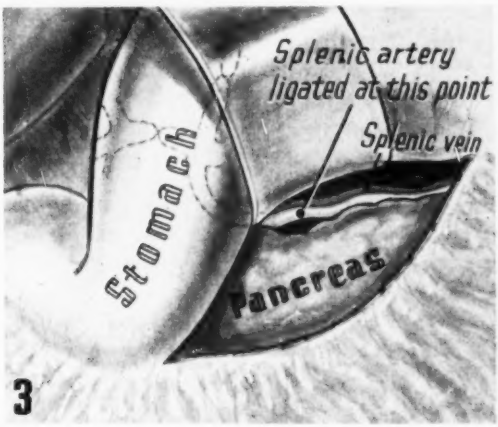


Fig. 3.—Approach to splenic artery through the gastrocolic ligament; stomach has been retracted upward.

we noted a change in systemic pressure due to the ligation of these vessels. The abdomen is closed without drainage, 00 and 000 surgical silk sutures being used throughout.

Postoperative Care.—The patient is permitted to take liquids as soon as nausea ceases. If parenteral fluids are needed, we use 5% dextrose in distilled water. Blood transfusions are given as indicated. Penicillin and streptomycin are con-

tinued in doses of 400,000 units of fortified penicillin morning and night and 0.5 gm. of streptomycin morning and night intramuscularly. Vitamin K is also continued in doses of 60 mg. a day. As soon as the patient is able to take food he is placed on a high-vitamin high-carbohydrate high-protein and low-fat diet. Supplementary vitamins and liver extract are administered parenterally. Cation-anion resins are used to aid in sodium elimination by the gastrointestinal tract until the kidneys begin to excrete normal amounts of this cation. Anions are removed to prevent acidosis. Potassium chloride is given as a supplement because this cation is excreted in large amounts by the kidneys in cirrhosis.

Postoperative Complications.—The bleeding tendency, as previously described, is the most serious of all complications. There is one other complication in addition to those which may occur in other types of abnormal surgery, namely, "hepatic crisis." We have observed it on the third or fourth day when splenectomy was done and not until about the eighth or ninth day if the spleen was not removed. The symptoms and signs of hepatic crisis resemble those of the "hepatorenal syndrome" and are probably due to hepatic as well as a renal insufficiency. Its chief manifestations are jaundice, ascites, general edema, lethargy, oliguria, fever, and low blood pressure. Laboratory studies show azotemia, impaired liver function, leucocytosis, anemia, and hypoproteinemia.

The treatment of "hepatic crisis" requires circumspect attention to water, electrolyte, and protein balance. The intravenous administration of dextrose in distilled water is usually supplemented by plasma and whole blood, particularly plasma because it has been found that the serum albumin becomes very low. We are careful not to overload the circulatory system with an excessive amount of fluid because of oliguria, which persists for about 24 to 48 hours. After this time all patients improved except one (M. N.) on the treatment outlined, and their immediate postoperative course was fairly smooth. Paracentesis has been necessary on one occasion in three patients after surgery. One man (P. B.) had, in addition to cirrhosis, a duodenal and a gastric ulcer for which subtotal gastrectomy was done at the time of the ligations. The other, a Lithuanian immigrant (J. L.) would not eat meat, and his protein requirements were not met by diet until food was brought in from home. The third (K. J.) had vomiting and diarrhea for about two weeks after surgery, depleting her protein reserves.

EVALUATION OF PHYSIOLOGICAL CHANGES PRODUCED IN CIRRHOSIS AFTER HEPATIC, SPLENIC, AND LEFT GASTRIC ARTERIAL LIGATIONS

We may evaluate the effect of ligations under the following heads: (*a*) change of clinical symptoms and signs; (*b*) physiological alterations in liver functions as determined by changes in portal pressure, laboratory tests, and hepatic blood flow, and (*c*) morphological changes as judged by the increase or decrease in size of the liver and by microscopic study of biopsy specimens obtained at the time of surgery and subsequently by needle puncture or of specimens obtained at autopsy.

Change of Clinical Symptoms and Signs.—The following symptoms have been listed and followed in evaluating clinical changes: 1. Feminization. This was noted in one man, and it disappeared after surgery. 2. Somnolence and lethargy. The only patients having this postoperatively were those who were going through "hepatic crises." 3. Hemorrhage and persistence of varices as determined by

x-ray and esophagoscopy. Two patients returned after surgery—one in four months and one in five months—with hemorrhage of which they died. All other patients had no further bleeding, from either the esophagus or the gastrointestinal tract, and, in at least two, the varices are not now demonstrable by x-ray or by esophagoscopy. A word should be said about the two patients who returned with bleeding varices. One of these, a woman (I. B.), had a 4+ Wassermann reaction of the blood and spinal fluid. She had already had three exsanguinating hemorrhages before surgery, but she continued her habit of consuming about a quart (0.9 liter) of whiskey a day. Her chief articles of diet were salt pork and bacon. Her renal clearance studies showed great improvement after surgery (Table 4), and after ligation of the hepatic and splenic arteries we found that her portal pressure was greatly reduced. We kept her in the hospital for approximately six weeks. After her release, she returned to her former diet of whiskey and salt pork, with recurrence of ascites and bleeding varices. She died of hemorrhage four months after surgery. Unfortunately, we did not obtain permission for autopsy; however, we did get a liver biopsy specimen, and it showed some questionable improvement in the morphology of liver structure (Fig. 4). The second patient was the man who had gastric and duodenal ulceration (P. B.). In spite of two-thirds gastric resection he returned with bleeding from esophageal varices. His stomach acids were low, and erosions were not apparent at autopsy. This man also had an excellent immediate postoperative result, but he was allowed to return to his work as taxi driver four weeks after surgery. Five months later he was back at his old haunts and his old habit of consuming large quantities of whiskey. He returned to the hospital in a moribund condition and died of bleeding varices, although we could not demonstrate these at autopsy. The liver was much larger than at operation (Fig. 5), and microscopic studies indicated changes which are difficult to evaluate. There seemed to be more fibrosis and yet a larger number of normal hepatic cells (Case 3). 4. Spider nevi. These have uniformly disappeared in these patients. 5. Weight loss. Our patients have lost weight. It has been relative rather than real because they have lost the ascites and the edema. However, after a while—and in one patient it took about six months—patients begin to put on weight again without an increase in extracellular water. 6. Vomiting and diarrhea. These did not occur after the operation except in one patient (K. J.). It disappeared in about two weeks. 7. Ascites. Ascites has diminished greatly, and in no patient who has survived, with the exception of the three mentioned, has a paracentesis been necessary. 8. Peripheral edema. This has improved greatly in all patients. 9. Liver. The liver has become palpable in two of our patients. This is a significant finding, we believe, because a continued reduction in the size of the liver indicates a progression of fibrosis. 10. Spleen. The spleen shrinks after splenic artery ligation then becomes greatly enlarged after a few months, ultimately becoming larger than it was at the time of operation. This is probably due to the splenic collateral circulation which develops. The same is true of the liver.[9] 11. Jaundice. Jaundice has occurred in three patients but was transient.

Physiological Alterations in Liver Functions as Determined by Changes in Portal Pressure, Laboratory Tests, and Hepatic Blood Flow.—In every case in which the portal pressure was measured, there was a fall immediately after the liga-

9. Berman,[1a] Ratnoff.[4]

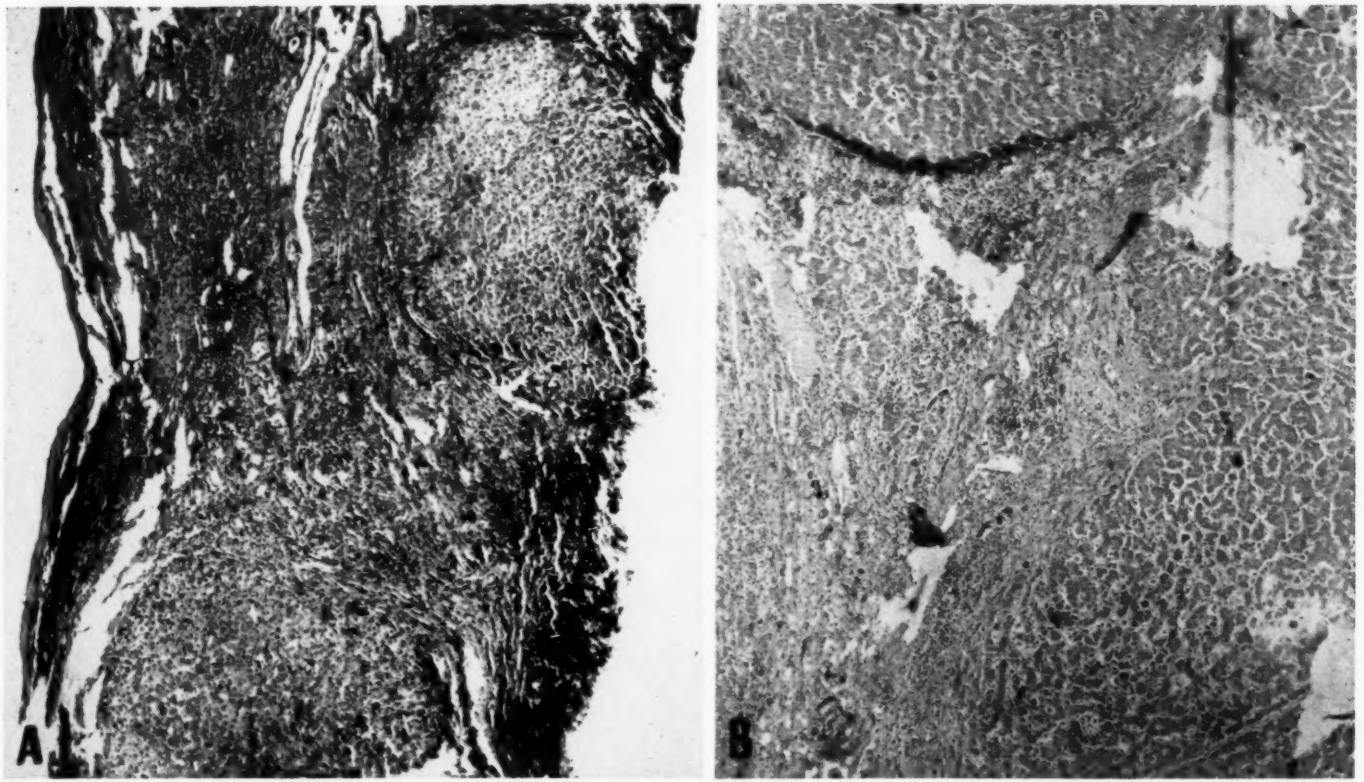


Fig. 4 (Case 2).—*A*, photomicrograph × 60 (hematoxylin and eosin stain) of biopsy specimen of liver taken at time of operation. Broad bands of dense fibrous periportal tissue heavily infiltrated by lymphocytes and polymorphonuclears and punctuated by many small bile ducts dissect liver tissue into misshapen lobules. *B*, photomicrograph × 60 of biopsy specimen of liver taken post mortem, five months after ligation and division of hepatic and splenic arteries. There are large distorted liver lobules separated from one another by moderately thick bands of fibrous tissue containing large numbers of lymphocytes and rare polymorphs and numerous bile duct reduplications. Fatty degeneration is absent. There are larger areas of regenerated liver parenchyma and fewer inflammatory cells.

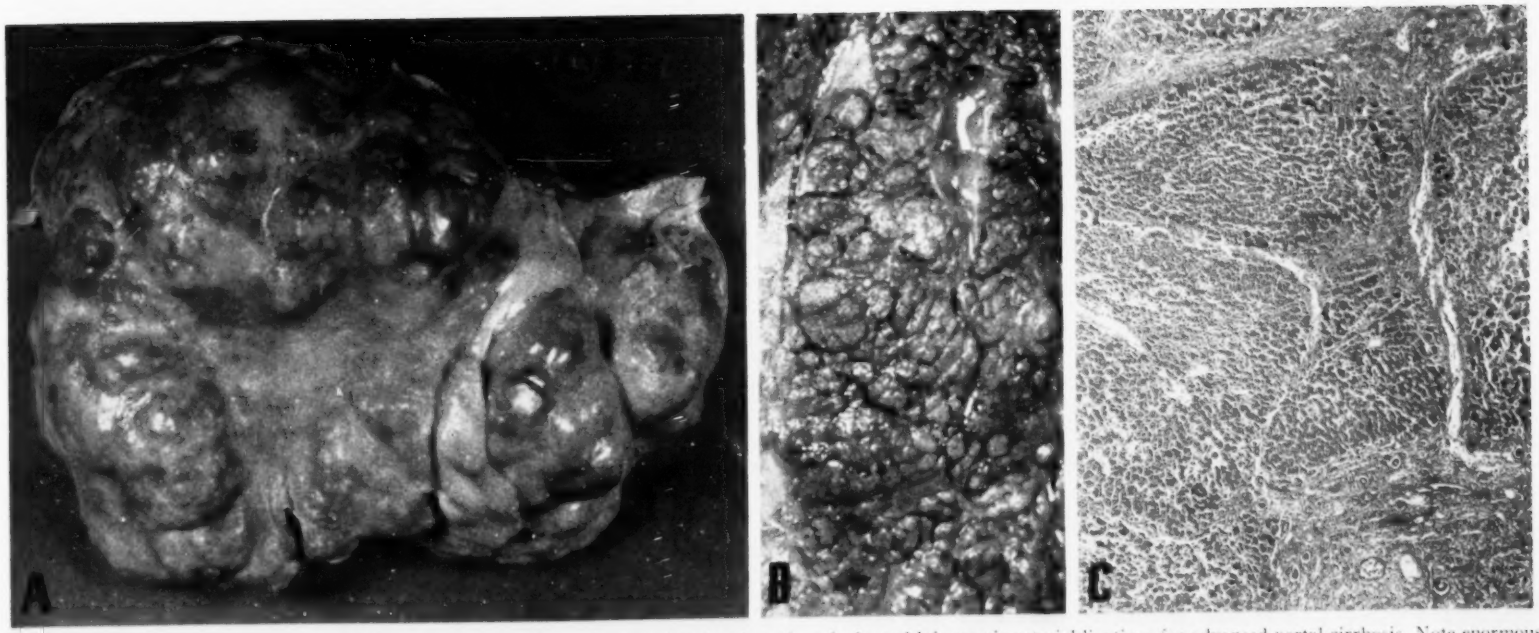


Fig. 5 (Case 3).—*A*, gross specimen of liver removed at autopsy five months after hepatic, splenic, and left gastric arterial ligations for advanced portal cirrhosis. Note enormous size of liver and prominent lobulations. *B*, cut surface showing large areas of regenerated parenchyma. *C*, photomicrograph × 32 (hematoxylin and eosin stain). Note increase in fibroplasia and vast areas of replacement fibrosis. Abundant regeneration of liver tissue is probably responsible for the increase in the size of the liver. Huge masses of regenerated parenchyma separated by large zones of fibrosis account for lobulation seen in gross specimen.

tions (Table 1). This was also found true by Altemeier,[10a] who at our suggestion operated upon a patient with cirrhosis and noted a portal pressure before ligation of 451 mm. of water. After ligation of the hepatic and splenic arteries it fell to 320 mm. of water, and there was a notable decrease in the tension and fullness of the veins in the omentum and the mesentery. This patient, as well as two others observed by Altemeier, has continued to improve without recurrence of ascites. Reynolds,[10b] after discussing the operation with us, ligated the common hepatic, gastroduodenal, left gastric, and splenic arteries in a cirrhotic patient with a portal pressure of 320 mm. of water. The pressure fell to 280 mm. but returned to its preligation level within 30 to 40 minutes. Swan [10c] ligated the hepatic, splenic, and left gastric arteries in two patients with advanced portal cirrhosis after conferring with us. In one the portal pressure fell from 400 to 240 mm. of water and in the other there was a marked reduction from a preligation portal pressure of 460 mm. of water. In both cases the sulfobromophthalein sodium excretion was increased after surgery. In one of these there was a change from 80% retention at 30 minutes

TABLE 1.—*Portal Pressures in Mm. of Sodium Citrate*

Patient	Before Ligation	After Ligation
Mr. E. H.	Not measured	Not measured
Mrs. I. B.	600 mm. (splenic vein)	380 mm.
Mr. P. B.	Not measured	Not measured
Mr. C. C.	330 mm. (omental vein)	240 mm.
Mr. J. L.	530 mm. (omental vein)	222 mm.
Mr. A. S.	385 mm. (omental vein)	318 mm.
Mrs. M. N.	345 mm. (omental vein)	202 mm.
Master J. B.	510 mm. (omental vein)	300 mm.
Mrs. E. B.	272 mm. (omental vein)	200 mm.
Mrs. K. J.	320 mm. (omental vein)	230 mm.
Mr. C. T.	380 mm. (omental vein)	348 mm.
Mr. H. O.	338 mm. (omental vein)	310 mm.

to 10% retention at 30 minutes. Benson [10d] treated a patient with portal cirrhosis in accordance with our plan and reported a fall in portal pressure and good clinical results. Reinhoff [10e] reported favorable results in six cases from ligation of the hepatic artery distal to the point of departure of the gastroduodenal and of the splenic artery close to the celiac axis. Our experiments showed a large incidence of hepatic necrosis from ligations of the hepatic artery at this site.

The sulfobromophthalein sodium test is a reliable prognostic guide because in most cases in which there was improvement in excretion of the drug the patients have continued to improve. All patients who recovered from surgery showed some improvement in sulfobromophthalein excretion (Table 2). This is a significant finding because it has been noted by Preshaw and his associates [11] that sulfobromophthalein excretion is lowered in most patients who have had portacaval shunts. It is our belief that with hepatic, splenic, and left gastric artery ligtations we are

10. (*a*) Altemeier, W. A.: Personal communication to the authors. (*b*) Reynolds, J.: Personal communication to the authors. (*c*) Swan, H.: Personal communication to the authors. (*d*) Benson, C.: Personal communication to the authors. (*e*) Rienhoff, W. F.: Ligation of the Hepatic and Splenic Arteries in the Treatment of Portal Hypertension with a Report on 6 Cases, Bull. Johns Hopkins Hosp. **88**:368, 1941.

11. Preshaw, D. E.; Large, A., and Johnson, A. F.: Effect of Portacaval Venous Shunt on Sulfobromophthalein (Bromsulphalein®) Retention, A. M. A. Arch. Surg. **62**:801, 1951.

likely to attract more, rather than less, portal blood to the liver, and the improvement in sulfobromophthalein excretion may be evidence of this fact. The other tests are equivocal. The one patient (C. T.) with hypersplenism showed a great rise in blood thrombocytes (platelets), erythrocytes, and leucocytes after splenectomy.

Hepatic blood flow, as studied by Bradley and his co-workers,[12] has not been studied in our patients. Habif [13] and his associates showed that hepatic extraction of sulfobromophthalein tended to rise as the effective hepatic blood flow fell during cyclopropane anesthesia, suggesting that the reduction in the flow of blood through the liver resulted in a more prolonged contact between extracting cells and blood containing sulfobromophthalein and thus permitted more efficient extraction. This view finds additional support in the observation that hepatic oxygen uptake increased sharply during the period of ischemia, with little or no alteration in the oxygen consumption. There is a decrease in blood flow in the cirrhotic liver, and, owing to venous stasis, there will be a greater loss of oxygen, but it is not necessarily taken up by the liver cells which may not have a chance to absorb it. The ischemia

TABLE 2.—*Comparison of Average Sulfobromophthalein Sodium Tests Before and After Surgery**

	Before Surgery				After Surgery		
Patient	15 Min. Retention, %	30 Min. Retention, %	45 Min. Retention, %	Date of Surgery	15 Min. Retention, %	30 Min. Retention, %	45 Min. Retention, %
Mr. E. H.	....	33.8	23.0	11/21/50	....	10.7	7.3
Mrs. I. B.	61.5	49.1	46.7	1/ 6/51	....	33.6	24.4
Mr. P. B.	55.0	32.1	....	2/ 8/51	....	....	12.3
Mr. J. L.	....	79.8	51.5	6/11/51	....	24.4	19.0
Mr. A. S.	....	24.0	....	6/22/51	....	15.9	11.1
Master J. B.	....	60.0	25.5	7/ 7/51	....	42.5	....
Mrs. K. J.	....	69.2	39.4	7/12/51	....	34.0	22.0
Mr. C. T.	....	10.7	7.3	8/25/51	....	....	7.0
			60 Min.				60 Min.
Mr. H. O.	....	14.4	2.5	8/30/51	....	9.7	2.7

* Sulfobromophthalein excretion improves progressively after surgery. The figures are averages for tests done at monthly intervals.

of hepatic parenchyma is based in part upon hepatic venous stasis and lack of sinusoidal flow.[14] After hepatic and splenic artery ligation venous stasis is decreased, thereby permitting a more rapid blood flow but at the same time permitting an easier uptake of oxygen by the liver cell.

Recent studies indicate a decrease in the arterial-portal venous oxygen difference in cirrhotics and a decrease in hepatic blood flow and sulfobromophthalein extraction. There is also an increase in hepatic venous pressure and a decrease in arterial-hepatic venous oxygen difference. These changes are probably due to a shunt mechanism between the hepatic artery and portal vein, and the hepatic artery and

12. Bradley, S. E.; Ingelfinger, F. J.; Bradley, G. P., and Curry, J. J.: The Estimation of Hepatic Blood Flow in Man, J. Clin. Invest. **24**:890, 1945. Bradley, S. E.: Variations in Hepatic Blood Flow in Man During Health and Disease, New England J. Med. **240**:456, 1951.

13. Habif, D. V.; Papper, E. M.; Fitzpatrick, H. F.; Lowrance, P.; Smythe, C. McC., and Bradley, S. E.: The Renal and Hepatic Blood Flow, Glomerular Filtration Rate and Urinary Output of Electrolytes During Cyclopropane, Ether, and Thiopental Anesthesia, Operation and the Immediate Postoperative Period, Surgery **30**:241, 1951.

14. Berman, J. K., and Hull, J. E.: Circulation in the Normal and Cirrhotic Liver, Ann. Surg., to be published.

hepatic vein, and the portal and hepatic veins, as previously described by one of us.[26] Such patients, who exhibit an increase in hepatic venous pressure, should benefit most from ligation of the hepatic, splenic, and left gastric arteries.

Morphological Changes as Judged by the Increase or Decrease in Size of the Liver and by Microscopic Studies from Biopsy Specimens Obtained at the Time of Surgery and Subsequently by Needle Puncture or at Autopsy.—It is very difficult to evaluate morphological changes without examining the entire liver. This has been done in one patient (P. B.), who died five months after operation. At autopsy his liver was greatly enlarged, and we felt that grossly it was much larger than at the time of operation. Microscopic studies based upon many sections and compared with slides made from biopsy specimens taken at the time of operation would seem to indicate that some regeneration had taken place. Certainly there was an increase in fibroblastic activity. This could indicate small areas of necrosis after ligation with scar formation. No evidence of massive infarction was found. Dr. William L. Drake, Jr., pathologist of the Indianapolis General Hospital, and Dr. Frank Forry, professor of pathology of the Indiana University School of Medicine, studied the sections thoroughly (Fig. 5) and came to the following conclusions:

> In our autopsy case, Mr. P. H. B., it was our opinion that the active fibroblastic proliferation seen microscopically and the vast areas of replacement fibrosis present grossly were indicative of healing of recent extensive damage, probably the result of interference with the vascular supply. It is quite possible that small multiple infarcts occurred following ligation of the hepatic artery and that these had healed successfully at the time of autopsy. Abundant regeneration present could easily account for the marked increase in size as compared to the apparent size of the liver at the time of operation. In this liver were seen masses of relatively normal liver cords (without true lobular arrangement, of course) which far exceeded in size anything seen in ordinary portal cirrhosis. These huge masses of regenerated parenchyma, separated by the large zones of fibrosis led us to originally feel that the picture might be that of post-necrotic fibrosis which is sometimes seen following an old episode of acute yellow atrophy.

Perfusions with the Herrick technique showed improvement over the usual ratio of pressures in the cirrhotic liver of 6 to 1. At 120 mm. of mercury in the hepatic artery the portal pressure was 12 mm., or a ratio of 10 to 1. This, however, falls far short of relationships observed in perfusions of the normal liver, in which 40 mm. of mercury is required to elevate the portal pressure 1 mm. of mercury.

Needle biopsy specimens have been obtained in three of our patients postoperatively. There is some improvement because there is less fibrosis, more normal liver parenchyma, and fewer inflammatory cells, although the small bits of tissue obtained may be misleading. However, in one patient (I. B.), who died five months after ligation, wedge biopsy specimens were obtained at operation and at necropsy. The principal change is in the number of inflammatory cells, which have definitely decreased (Fig. 4).

SECONDARY EFFECTS OF THE PROCEDURE

The secondary effects of the procedure have been estimated by renal clearance studies and the excretion of sodium. There is, apparently, an improvement in renal function (Tables 3 and 4), and the hyponatruria is relieved. The exact explanation for this is not clear. However, it is felt that it is secondary to ligation because many of these patients had renal clearance studies repeatedly before surgery, and, in spite of resin treatment, no changes could be detected.

Perhaps the decreased urinary output in cirrhotics is due to an excessive amount of circulating antidiuretic hormone from the posterior lobe of the pituitary gland. It is thought by many observers that this hormone is normally detoxified or inactivated by the liver. It would follow, then, that in cirrhosis, with liver function greatly decreased, there would be an excessive amount of antidiuretic hormone, which would increase the reabsorption of water and salt by the tubular cells. When the amount of antidiuretic principle of the pituitary diminishes by after-

TABLE 3.—*Average Plasma Sodium and Urinary Sodium* *

	Before Surgery			After Surgery	
Patient	Plasma Sodium, mEq. per L.	Urinary Sodium, mEq. per 24 Hr.	Date of Surgery	Plasma Sodium, mEq. per L.	Urinary Sodium, mEq. per 24 Hr.
Mr. E. H.....	140	2 mEq. in 800 ml. of urine	11/21/50	136	126.4 mEq. in 1,620 ml. of urine
Mrs. I. B.....	142.7	29.4 mEq. in 2,100 ml. of urine	1/ 6/51	139.5	70.1 mEq. in 2,183 ml. of urine
Mr. P. B.....	149.2	4 mEq. in 720 ml. of urine	2/ 8/51	147.5	39 mEq. in 1,560 ml. of urine
Mr. J. L.....	132.2	0.9 mEq. in 460 ml. of urine	6/11/51	136.6	11.2 mEq. in 225 ml. of urine
Mr. A. S.....	147	21 mEq. in 1,500 ml. of urine	6/22/51	139.5	32 mEq. in 1,735 ml. of urine
Master J. B.....	193.4	28 mEq. in 1,600 ml. of urine	7/ 7/51	142	60.8 mEq. in 1,000 ml. of urine
Mrs. K. J.....	143.5	1.8 mEq. in 2,625 ml. of urine	7/12/51	140	163.4 mEq. in 1,800 ml. of urine
Mr. C. T.....	.....	.....	8/25/51	.....	77 mEq. in 3,600 ml. of urine
Mr. H. O.....	139.3	1.1 mEq. in 1,000 ml. of urine	8/30/31	.....	8 mEq. in 660 ml. of urine

* The sodium excretion increases gradually after surgery. The above figures are averages for tests done at monthly intervals. In general, the degree of improvement is proportional to the length of the postoperative period. Note that the plasma sodium remains comparatively stable in spite of the wide variations in urinary sodium. Diet per 24 hours contained 1.5 gm. (65.2 mEq.) of sodium.

TABLE 4.—*Renal Clearances Before Surgery* *

Name	Date	Renal Blood Flow, Cc./Min.	Iodopyracet Clearance, Cc./Min.	Inulin Clearance, Cc./Min.	Filtration Fraction	Tmp	Renal Blood Flow/Tmp	Plasma Sodium, mEq.	Urinary Sodium
				Before Surgery					
Mrs. I. B.	1/ 4/51	737	508	82	0.162	49.6	14.86	142.7	29.4 mEq. per 2,100 ml. urine
Mrs. K. J.	7/ 9/51	741	526	92	0.175	42	17.8	143.5	1.8 mEq. per 2,625 ml. urine
				After Surgery					
Mrs. I. B.	17 days postoperatively 1/25/51	1,121	638	110.1	0.173	56.8	19.74	139.5	70.1 mEq. per 2,183 ml. urine
Mrs. K. J.	46 days postoperatively 8/28/51	1,035	673	97	0.145	46.6	22.2	140	163.4 mEq. per 1,800 ml. urine

* Study of renal clearances before and after surgery in Mrs. I. B. and Mrs. K. J. Renal blood flow is calculated on the basis of iodopyracet (diodrast®) plasma clearance corrected from the hematocrit. Normal flow is 1,000 to 1,200 cc. per minute. Iodopyracet clearance indicates renal plasma flow in both glomerulus and tubules and normally equals 550 to 625 cc. per minute. Inulin clearance measures the excretory function of the glomerulus which is normally 80 to 125 cc. per minute. The filtration fraction is inulin clearance divided by the iodopyracet clearance and is the part of the total blood flow through the kidney that filters through the glomerulus. Normal is 0.17 to 0.21. Tmp denotes tubular mass iodopyracet and is the number of milligrams cleared by the tubules per minute. It is a measure of the amount of active tubular function and normally is 42 to 54 mg. per minute. Renal blood flow Tmp is a fraction designed to express the amount of blood flowing through active tubules or the cubic centimeters of blood flowing through each unit of tubular mass. This is normally 18 to 22. Note the improvement in kidney function as determined by renal clearance before and after surgery. However, the enormous increase in excretion of urinary sodium cannot be explained entirely on a basis of renal hemodynamics, as determined by the above tests.

ent nerve impulses or is diluted by an excessive amount of water, diuresis follows. If the organ of inactivation of this hormone is the liver, increased urinary output would be another evidence of improved hepatic function following ligation of the hepatic and splenic arteries.

A change in blood pressure has not been a prominent feature in any case. We have watched the blood pressure by sphygmomanometer readings at frequent intervals, and this has been constant. In one patient the angiotonin units were measured

TABLE 5.—*Summary of Data on Patients with Advanced Portal Cirrhosis Who Underwent Operation*

Name	Age, Yr.	Date of Operation	Clinical Status	Death	Autopsy and Report
Mr. E. H.	61	11/21/50	Much improved, urinary output increased; little recurrence of ascites; no paracentesis since surgery; appetite improved; weight increase (real)	.....	.....
Mrs. I. B.	41	1/ 6/51	Greatly improved for 3 months, then repeated hemorrhages from varices and recurrence of ascites	May 27, 1951	No autopsy; post-mortem liver biopsy; moderate portal cirrhosis
Mr. P. B.	45	2/ 8/51	Greatly improved for 5 months, no ascites or bleeding varices	July 8, 1951, 5 months following surgery from hemorrhage due to bleeding esophageal varices	1. Cirrhosis of the liver 2. Dependent pulmonary congestion
Mr. C. C.	48	3/19/51	.....	March 21, 1951, 3 days following surgery	1. Massive hemorrhage from ruptured esophageal varices 2. Cirrhosis of the liver 3. Pulmonary edema
Mr. J. L.	68	6/11/51	Appetite improved; 2 paracenteses since surgery; no ascites recently	.....	.....
Mr. A. S.	65	6/22/51	Greatly improved, no ascites	.....	.....
Mrs. M. N.	58	6/29/51	.....	July 1, 1951, 2 days following surgery	1. Ligated hepatic and splenic arteries near celiac axis 2. Portal cirrhosis 3. Atelectasis of lower lungs bilaterally 4. Marked coronary atherosclerosis
Master J. B.	10	7/ 7/51	Greatly improved, no ascites	.....	.....
Mrs. E. B.	59	7/10/51	.....	July 10, 1951, continued bleeding from varices	.....
Mrs. K. J.	44	7/12/51	Greatly improved, no ascites	.....	.....
Mr. C. T.	69	8/25/51	Greatly improved, no ascites	.....	.....
Mr. K. O.	63	8/30/51	Greatly improved, no ascites	.....	.....

before and after surgery; there was a slight rise, but this was considered of no significance. We are at present engaged in the experimental evaluation of hepatic angiotonin relationships.

MORTALITY

The death of three patients within the first week after operation and two others within the year gave an immediate mortality of 25% an an over-all mortality of 41.6%. It should be borne in mind, however, that these patients were all designated as hopeless, with a life expectancy of a few months at most, with the exception of the 10-year-old boy with portal cirrhosis and congestive splenomegaly. This boy did have ascites and portal hypertension; but he did not have esophageal varices. His liver, however, was cirrhotic, and the microscopic picture was typical (Table 5).

COMMENT

We have tried to explain the effects of this procedure and the modus operandi of its behavior.[2b] In brief, it was stated that the normal liver may be compared to an elastic sponge in which the hepatic arterial inflow with a pressure of 120 mm. of mercury meets the portal venous inflow with a pressure of 12 mm. of mercury in the sinusoids, and here, because of the elasticity of the liver, the pressures are reduced to a common value. We have also averred that the sinusoids represent a primitive form of circulation very much like that in the glomerulus in the kidney, and that, unlike other forms of circulation in the body, this circulation does not have an arterial and a venous component. In other words, the blood does not flow in two directions. It is a continuous slow flow so that the cells that are adjacent to it can derive the greatest amount of food and oxygen. At the same time it should be remembered that an arterial inflow into such a straight system could be effectively reduced without the normal elasticity surrounding it. It is our premise that this is what happens in cirrhosis of the liver. The elasticity is gone; the hepatic arterial pressure remains high. There is a dissociation between portal sinusoids and hepatic veins, with a consequent rise in portal pressure. Collaterals tend to form between the portal and the hepatic veins in the liver and between the portal and the systemic veins outside in an effort to circumvent the liver in the latter instance and in an effort to form an internal Eck fistula in the former. Collaterals also form between the hepatic artery and the portal vein and also between the hepatic artery and the hepatic veins within the liver substance. This, we think, constitutes what may be compared to a cavernous hemangioma. It was termed an angiomatous transformation by earlier pathologists, and this has been confirmed by recent observers, as pointed out in previous communications.[2b] By interrupting the hepatic arterial inflow and reducing the pressure in this circuit, the liver gets its arterial blood through many collaterals. This decreases the capillary arterial pressure so that a common pressure level is again restored in the primitive sinusoids, thereby permitting a greater volume of portal blood to enter the liver. We are in agreement with Grindlay, Mann, and Bollman[15] that cirrhosis of the liver can be ameliorated only by a greater inflow of venous blood, not by its exclusion.

There is much work left to be done, and subsequent reports will be made as experience accumulates. We feel that with a more careful selection of cases and with improvement in technique our mortality rate should be lower. Perhaps, operation before the advanced state may yield better results in cases of this type.

CONCLUSIONS

Ligation of the hepatic, splenic, and left gastric arteries in patients with advanced portal cirrhosis is a rational procedure which alleviates many of the serious complications and aids in the production of hepatic vascular compensation. Esophageal venous pressure is reduced by occlusion of the left gastric artery and is therefore an added safeguard in the presence of esophageal varices. Supplementary therapy with cation-anion resins and strict dietary control should be employed postoperatively to attain the best immediate results. This combination of medical and surgical management may interrupt the fatal progress of the disease.

15. Grindlay, J. H.; Mann, F. C., and Bollman, J. C.: Discussion Before the Central Surgical Association, Chicago, Feb. 23, 1951.

REPORT OF CASES

CASE 1.—E. H., a white man aged 61, was first admitted to the Indianapolis General Hospital on Feb. 27, 1949. His illness began 18 months previously with anorexia, ascites, edema of the ankles, and a 60 lb. (27.2 kg.) weight loss. For the past 30 years he had consumed 6 to 10 bottles of beer and 1 to 2 pints of whiskey a day. He had a large umbilical hernia, which increased in size because of the ascites. Laboratory findings were as follows: The blood cell count showed 5,500,000 erythrocytes, 13 to 14.5 gm. of hemoglobin and 10,300 leucocytes. The urine contained a faint trace of albumin and a few finely granular casts but was otherwise normal. The value for total protein was 5.6 gm. (albumin 1.8 gm. and globulin 3.8 gm.). The results of the sulfobromophthalein sodium test varied, but the average was 33.8% retention at 30 minutes and 23% retention at 45 minutes; cephalin flocculation at 24 hours was 1+ and at 48 hours 2+; thymol turbidity was 3 Maclagan units. The colloidal red test gave a reading of 3+. The serum bilirubin level was 0.682 mg. per 100 cc.; the prothrombin time, 62% of normal, and the alkaline phosphatase, 14.0 King-Armstrong units. The average urinary sodium level was 2 mEq. in 800 ml. of urine per 24 hours. The serologic reaction for syphilis was negative.

Treatment consisted of high-protein low-salt diet, cation resins and paracenteses, averaging 17,055 cc. of fluid a month. The hepatic and splenic arteries were ligated on Nov. 21, 1950. At the time of surgery 7,500 cc. of ascitic fluid was aspirated. Liver biopsy specimens showed advanced portal cirrhosis. After operation there was great improvement in all symptoms. The patient became more alert, his appetite returned, and there was no further bleeding from the gastrointestinal tract. His weight has remained constant. There has been no vomiting or diarrhea, and the ascites has not recurred. There is no peripheral edema and no jaundice, and the spleen is now slightly palpable. The patient took cation-anion resins for about four months but is taking no medicine at present, and he is eating 3 gm. of sodium a day with a regular diet. Laboratory tests now give the following values: Erythrocytes number 4,800,000, with 13.9 gm. of hemoglobin, and leucocytes number 8,000. Urinalysis shows a faint trace of albumin and a few finely granular casts. The total protein value is 6.7 gm. (albumin 2.7 gm. and globulin 4 gm.) The sulfobromophthalein retention is 10.7% at 30 minutes and 7.3% at 45 minutes; cephalin flocculation at 24 hours is 1+ and at 48 hours 1+; thymol turbidity is 5 units, and the colloidal red test gives a 1+ reading. The serum bilirubin is 0.610 mg. per 100 cc. The prothrombin time is 86% of normal. The urinary sodium excretion now averages 126 mEq. in 1,620 ml. of urine per 24 hours. There has been no change in blood pressure and no increase in angiotonin units.

CASE 2.—Mrs. I. B., a white woman aged 41, was admitted to the Indianapolis General Hospital on Dec. 28, 1950, complaining of a swelling of the abdomen and swollen ankles. Four months previously she had been in the hospital for a period of about two weeks because of her third episode of severe esophageal bleeding. At the age of 8 years she was hospitalized for tuberculosis but the disease was declared arrested or cured in about nine months. In 1932 she received intensive treatment for syphilis. However, she did not continue with the treatment because of persistent jaundice. The patient had had repeated paracenteses yielding 3,000 to 7,000 cc. of fluid at a time. Laboratory findings were as follows: erythrocytes 3,080,000, hemoglobin 9.4 gm., leucocytes 4,450; results of urinalyses, normal; total protein, 6.6 gm. (albumin 2.5 gm. and globulin 4.1 gm.); sulfobromophthalein retention, 61.5% at 15 minutes, 49.1% at 30 minutes, and 46.7% at 45 minutes; cephalin flocculation at 24 hours, 3+, and at 48 hours, 4+; thymol turbidity, 7.5 units; colloidal red test result, 3+; serum bilirubin, 4.81 mg. per 100 cc.; prothrombin time, 50% of normal; alkaline phosphatase, 12.9 King-Armstrong units; urinary sodium, 29.4 mEq., with 2,100 ml. of urinary output; serologic reaction for syphilis, 4+. The results of renal clearance studies were as follows: renal blood flow, 737 cc. per minute; iodopyracet (diodrast®) clearance, 508 cc. per minute; inulin clearance, 82 cc. per minute; filtration fraction, 0.162; T_{m_D}, 49.6; renal blood flow/T_{m_D}, 14.86. The sodium in the diet was 1.5 gm., and the plasma sodium was 142.7 mEq. per liter.

Ligation and division of hepatic and splenic arteries was carried out on Jan. 6, 1951. At the time of surgery 5,000 cc. of fluid was removed from the abdomen. A liver biopsy specimen showed severe portal cirrhosis (Fig. 4). The portal pressure was 600 mm. of sodium citrate solution in the splenic vein. After ligation of the hepatic and splenic arteries the pressure

dropped to 380 mm. of citrate solution. The postoperative course was smooth, and symptoms were greatly relieved. There was weight loss at first but no vomiting or diarrhea and no reaccumulation of ascites or peripheral edema. There was slight jaundice, which persisted for about two weeks and then disappeared. Thirteen weeks after operation, laboratory studies showed the following values: erythrocytes 3,300,000, hemoglobin 9.5 gm., leucocytes 4,000; results of urinalyses, normal; total proteins, 7.1 gm. (albumin 2.2 gm. and globulin 4.9 gm.). The sulfobromophthalein test showed 33.6% retention at 30 minutes and 24.4% retention at 45 minutes; cephalin flocculation at the end of 24 hours was 3+; thymol turbidity was 15 units; the colloidal red test reading was 3+, and the serum bilirubin level was 1.13 mg. per 100 cc. The prothrombin time was 43% of normal. The urinary sodium was 70.1 mEq. in 2,183 ml. of urine; renal blood flow, 1,121 cc. per minute; iodopyracet clearance, 638 per minute; inulin clearance, 110.1 cc. per minute; filtration fraction, 0.173, Tm_b, 56.8; renal blood flow/Tm_b, 19.74; plasma sodium, 139.5 mEq. Studies of angiotonin units showed a slight rise after surgery, from 1.55 units per cubic centimeter of plasma to 1.8 units per cubic centimeter of plasma, although clinically the blood pressure remained constant. The patient was dismissed from the hospital greatly improved, but she returned five months after operation with bleeding from esophageal varices. The ascitic fluid had reaccumulated, and there was vomiting of blood and diarrhea. The patient stated that her principal article of diet since leaving the hospital was salt pork and that she consumed alcoholic beverage daily. She died 10 days after admission of an exsanguinating hemorrhage. Permission for autopsy was denied; however, a biopsy specimen from the liver was taken post mortem. This showed a decrease in inflammatory cells. There was no evidence of liver necrosis and no other changes which were significant (Fig. 4).

Case 3.—P. B., a white man 45 years of age, was admitted to the Indianapolis General Hospital on Jan. 24, 1951, complaining of abdominal pain, ascites, and hematemesis. He had been treated for cirrhosis during the past four years. Repeated paracenteses yielded from 2,000 to 5,000 cc. of fluid at a time. The patient was known to have a gastric ulcer which was poorly controlled medically, chiefly because the patient refused to stay on his diet. For two years prior to his last admission he had repeated hemorrhages which were thought to be due to a bleeding ulcer. However, x-ray examination and esophagoscopy confirmed the fact that the patient had esophageal varices as well as a gastric ulcer. Laboratory examinations at the time of admission provides the following data: Erythrocytes numbered 3,200,000, with 9.5 gm. of hemoglobin, and leucocytes numbered 9,900. Urinalysis disclosed a faint trace of albumin, 4 or 5 white blood cells per high power field, and a few granular casts. The total protein of the blood was 8.4 gm. (albumin 3.2 gm., and globulin 5.2 gm.). A sulfobromophthalein sodium test showed 55% retention at 15 minutes and 32.1% retention at 30 minutes; cephalin flocculation at 24 hours was doubtful and at 48 hours was 4+; thymol turbidity was 10 units. The colloidal red test gave a 1+ reading and the serum bilirubin level was 0.264 mg. per 100 cc. The prothrombin time was 54% of normal, and the alkaline phosphatase 5.4 King-Armstrong units. The average urinary sodium level was 4 mEq. in 720 ml. of urine per 24 hours. The Wassermann reaction was negative; nonprotein nitrogen, 30 mg. per 100 cc. At the time of surgery, on Feb. 8, 1951, large gastric and duodenal ulcers were found; therefore, a subtotal gastric resection was done, and at this time the hepatic artery was ligated doubly and divided. The splenic artery was also doubly ligated and divided. The continuity of the gastrointestinal tract was reestablished by an anterior Polya type of anastomosis. After surgery the patient had a relatively smooth convalescence until the 10th day, when symptoms and signs of "hepatic crisis" with ascites developed. Paracentesis was necessary on one occasion. X-ray studies after a barium meal six weeks after surgery showed a persistence of varices, with a good functioning stoma. There was no further bleeding, and the patient began to gain weight without ascites or edema. Four weeks following surgery the findings on laboratory tests were as follows: erythrocytes 4,000,000, hemoglobin 10 gm., and leucocytes 7,000; results of urinalyses, normal; total proteins, 8 gm. (albumin 2 gm. and globulin 6 gm.); sulfobromophthalein retention, 12.3% at 45 minutes; cephalin flocculation at 24 hours, 3+, and at 48 hours, 4+; thymol turbidity, 15 units; colloidal red test results, 3+; serum bilirubin, 0.682 mg. per 100 cc.; prothrombin time, 85% of normal; plasma sodium, 147.5 mEq. per liter; urinary sodium, 39 mEq. in 1,560 ml. of urine. The patient remained clinically well for about five months after surgery. During this period he had

no complaints and returned to his job as a taxicab driver. He soon strayed from his low salt diet and reembraced his habit of consuming large quantities of whiskey. He returned to the hospital on July 8, 1951, bleeding from esophageal varices, and before any measures could be instituted the patient died of acute blood loss. Permission for autopsy was obtained and a postmortem photograph of the gross specimen of the liver is shown in Figure 5. The interesting morphological change was the great increase in size of the liver. Microscopic study cannot be quantitative because of the small preoperative specimen. However, there seems to be a greater amount of fibrosis together with an increase in the areas of normal liver parenchyma and a decrease in the numbers of inflammatory cells.

Case 4.—C. C., a white man 48 years of age, was admitted to the Indianapolis General Hospital on Feb. 13, 1951, complaining of ascites and bleeding varices which had persisted for three years with two hemorrhages within the past six weeks. He also complained of pain in the right upper abdominal quadrant which was of eight weeks' duration. He was a heavy drinker but stated that his preference was for beer rather than whiskey. Repeated paracenteses yielded 7,000 to 10,000 cc. of ascitic fluid. Four weeks after admission, while the patient was under treatment, hematemesis recurred and persisted in spite of transfusions and intraluminal compression with the Patton-Johnston tube; surgery was deemed necessary to control the bleeding. Laboratory studies prior to the last series of hemorrhages showed the following results: erythrocytes 3,110,000, hemoglobin 12.5 gm., leucocytes 8,300; results of urinalysis, normal. The total protein values were 7.3 gm. (albumin 3.2 gm. and globulin 4 gm.). The sulfobromophthalein test showed 48.5% retention at 30 minutes and 34.9% retention at 45 minutes; cephalin flocculation was 4+ at 24 hours and 4+ at 48 hours; thymol turbidity was 20 units; the colloidal red test reading was 4+, and the serum bilirubin level was 1.18 mg. per 100 cc. The prothrombin time was 30% of normal; alkaline phosphatase, 2.4 King-Armstrong units; Wassermann reaction, negative, and nonprotein nitrogen, 12 mg. per 100 cc. On March 19, 1951, the patient's condition was desperate. He had received a total of 2,000 cc. of blood prior to surgery, but his blood pressure remained at 70 systolic and 30 diastolic. In a frantic effort to arrest hemorrhage, exploration was carried out through a left upper paramedian incision, and 12,000 cc. of ascitic fluid was removed. The portal pressure was found to be 330 mm. of citrate, as measured in an omental vein. The esophageal varices were ligated through an incision in the cardia, and at the same time the hepatic, the left gastric, and the splenic artery were doubly tied. After this procedure the portal pressure dropped to 240 mm. of citrate. The patient remained in a state of shock during the operation, and after three days he died of continued blood loss. Autopsy was done, and in addition to the cirrhosis of the liver, extensive pulmonary edema was found.

Case 5.—J. L., a white man 68 years of age, was admitted to the Indianapolis General Hospital on March 28, 1951, complaining of edema of the legs and ankles and dyspnea. He was a retired Lithuanian meatpacker and had been a heavy drinker for over 40 years. We learned from relatives that within the past four or five years he had consumed large quantities of whiskey and wine daily. On March 31, we obtained 13,200 cc. of ascitic fluid, and similar amounts were obtained at frequent intervals. This patient had all the symptoms and signs of portal cirrhosis and, in addition, showed the greatest amount of ascitic accumulation of any patient that we have had to date, his average being approximately 19,600 cc. per month. The laboratory data (average) were as follows: Erythrocytes numbered 3,100,000, with 13 gm. of hemoglobin, and leucocytes numbered 10,150. Urinalysis disclosed a faint trace of albumin, and 6 or 7 white blood cells per high power field. The total protein of the blood was 6.1 gm. per 100 cc. (albumin 2.2 gm. and globulin 3.9 gm.). A sulfobromophthalein test showed 79.8% retention at 30 minutes and 51.5% retention at 45 minutes; cephalin flocculation at 24 hours was doubtful and at 48 hours was 2+; thymol turbidity was 2 units; the colloidal red test gave a 1+ reading and the serum bilirubin level was 2.99 mg. per 100 cc. The prothrombin time was 80% of normal; alkaline phosphatase, 8.1 King-Armstrong units; plasma sodium, 132.2 mEq. per liter; urinary sodium, on a diet of 1.5 gm. (65.2 mEq.), 0.9 mEq. in 460 ml. of urine per 24 hours; Wassermann reaction, negative; renal blood flow, 300 cc. per minute; iodopyracet clearance, 179 cc. per minute; inulin clearance, 30 cc. per minute; filtration fraction, 0.17; Tm_D, 21; renal blood flow/Tm_D, 14. At the time of surgery (June 11, 1951) 14,000 cc. of ascitic fluid was aspirated. The portal pressure in an omental vein prior to ligation of the hepatic and splenic arteries was 530 mm. of citrate and after ligation it was 222 mm. of citrate. The liver was extremely small;

appearing to be about one-third the normal size. After surgery the patient had a very stormy convalescence, having two attacks of "hepatic crisis" during which time he became comatose and the ascites recurred; paracenteses was required on two occasions, yielding 10,000 cc. and 8,000 cc. of fluid. He was a difficult patient to direct because he could not understand English, and he refused to take resins; moreover, he would not eat because he said that his diet, which contained 1.5 gm. of sodium, was not tasty. We soon learned that he would not eat unless we acquiesced to his demands, and therefore he was given a regular diet with unlimited salt. Four weeks postoperatively there was still very little improvement in his condition, and the following laboratory results were obtained: erythrocytes 4,700,000, hemoglobin 12.2 gm. per 100 cc.; results of urinalysis, normal. The value for total protein was 6.8 gm. (albumin 2.4 gm. and globulin 4.4 gm.); sulfobromophthalein retention was 24.9% at 30 minutes and 19% at 45 minutes; cephalin flocculation at 24 hours was doubtful, and at 48 hours 1+; thymol turbidity was 3 units. The colloidal red test gave a 3+ reading. The serum bilirubin level was 3.63 mg. per 100 cc.; prothrombin time, 80% of normal; plasma sodium, 136.6 mEq. per liter; urinary sodium, 11.2 mEq. in 225 ml. of urine. At present the patient is showing clinical improvement.

Case 6.—A. S., a white man 65 years of age, was admitted to the Indianapolis General Hospital on June 19, 1951. Ten months before admission he noted that his abdomen and legs were greatly swollen. His liver was enlarged to about 2½ in. (6.3 cm.) below the costal margin, but his spleen was not palpable. The ascites had caused his inguinal hernia to increase greatly in size within the past month. His blood pressure was 100 systolic and 58 diastolic. He drank beer occasionally, although this was not a daily habit. He had vomited occasionally with specks of blood, but there had been no large quantities of blood, although at times the stools were black. The laboratory data were as follows: erythrocytes 4,030,000, hemoglobin 12.8 gm., leucocytes 10,300; urinalysis, normal; total protein, 5.3 gm. (albumin 2.2 gm. and globulin 3.2 gm.); sulfobromophthalein retention, 24% in 30 minutes; prothrombin time, 79% of normal; plasma sodium, 147 mEq. per liter; and urinary sodium, 21 mEq. in 1,500 ml. of urine. Approximately 9,000 cc. of ascitic fluid was removed from the abdomen at the time of operation, on June 22, 1951. The portal pressure was 385 mm. of citrate in an omental vein. After ligation of the hepatic and splenic arteries the portal pressure was 318 mm. of citrate. The patient's postoperative course was smooth, and there was no hepatic crisis. Liver biopsy specimens showed an advanced portal cirrhosis. On Sept. 5, two and one-half months after surgery the patient was greatly improved. There had been no recurrence of the ascites or edema; appetite was excellent, with a gain of 5 lb. (2.3 kg.) in weight. Laboratory tests were as follows: erythrocytes 4,220,000, hemoglobin 12.1 gm.; leucocytes 8,900. The sulfobromophthalein test showed 15.9% retention at 30 minutes and 11.1% retention at 45 minutes; plasma sodium, 139.5 mEq. per liter; and urinary sodium, 32 mEq. in 1,735 ml. of urine during 24 hours. Esophageal varices were still demonstrable but not bleeding.

Case 7.—M. N., a white woman aged 58, was admitted to the Indianapolis General Hospital on June 22, 1951, complaining of abdominal swelling and edema of the ankles. She had been under medical treatment for the past three years, but her abdomen had increased so much in size within the past three months that it was difficult for her to breathe. Her blood pressure was 230 systolic and 110 diastolic. The heart was greatly enlarged, and a loud murmur was heard over the apex. X-ray examination showed an enlarged heart, but all other studies were normal. There were no varices at the time of the barium swallow, although the patient stated that on one occasion she had vomited a slight amount of blood. Laboratory findings were as follows: erythrocytes 4,180,000; hemoglobin 13.0 gm.; leucocytes 6,450. Urinalysis was normal; Bence Jones protein, negative; total protein, 6.5 gm. per 100 cc. (albumin 3.6 gm. per 100 cc. and globulin 2.9 gm. per 100 cc.); sulfobromophthalein retention, 1.5% at 30 minutes and 0.3% retention at 45 minutes; prothrombin time, 100% of normal, nonprotein nitrogen, 49 mg. per 100 cc. A biopsy specimen of the liver showed portal cirrhosis. We thought that this was an early case that should yield excellent results from surgery. On June 29, 1951, the abdomen was explored through a transverse incision. Portal pressure was 345 mm. of citrate. After ligation of the hepatic and splenic arteries, the pressure fell to 202 mm. of citrate. On the second postoperative day the patient became anuric and stuporous from "hepatic crisis" and died in spite of measures we had used successfully in similar cases. At autopsy the ligatures were checked and found to be close to the celiac axis on the common hepatic artery and on the splenic

artery. There were small areas of hemorrhage in the capsule of the spleen and of the liver and around the esophagus and in the pericardium. There was an advanced portal cirrhosis, atelectasis of the lower lobes of the lungs, and severe coronary atherosclerosis.

Case 8.—J. B., a 10-year-old white boy, was admitted to St. Vincent's Hospital on July 1, 1951, with a diagnosis of Banti's syndrome. He had been sick at intervals for three years and became jaundiced in June, 1950, and this condition persisted for nine months. During this time he had acholic stools and choluria. The liver was palpable about 1½ in. (3.8 cm.) below the costal margin, and the spleen extended to the brim of the pelvis. A moderate amount of ascites was present. There had been no vomiting of blood, and esophageal varices were not demonstrable by x-ray. Results of laboratory studies were as follows: erythrocytes, 3,990,000; hemoglobin, 11.4 gm.; leucocytes, 3,950, with 4% stab cells, 47% segmental cells, 51% total polymorphonuclear leucocytes, 46% lymphocytes, 2% eosinophiles, and 1% basophiles. Bone marrow studies were normal. The serum protein value was 6.4 gm. per 100 cc. (albumin 3.5 gm., and globulin 2.85 gm.). The sulfobromophthalein test showed 60% retention at 30 minutes and 25.5% retention at 45 minutes; cephalin flocculation at 24 hours was 4+ and at 48 hours 4+; thymol turbidity was 4 Maclagan units. The serum bilirubin level was 2.4 mg. per 100 cc.; prothrombin time, 70% of normal; plasma sodium, 193.4 mEq. per liter; urinary sodium, 28 mEq. in 1,600 ml. of urine in 24 hours; nonprotein nitrogen, 28 mg. per 100 cc.; blood sugar, 87 mg. per 100 cc.; carbon-dioxide-combining power 48 vol. %. The patient was operated upon July 7, 1951. A large nodular liver extending 2 in. (5 cm.) below the costal margin was encountered, and the spleen filled the entire left side of the abdomen. About 500 cc. of ascitic fluid was aspirated. The portal pressure was 510 mm. of citrate. The hepatic artery was triply ligated, the splenic artery was tied close to the celiac axis, and a splenectomy was done. After splenectomy and ligation of the hepatic artery, the portal pressure was 300 mm. of citrate. Liver biopsy specimens showed advanced portal cirrhosis, and the spleen was described as diffusely hyperplastic. The patient is now well clinically, and there has been no recurrence of ascites. Laboratory studies on Oct. 6, three months after surgery, gave the following results: erythrocytes, 4,300,000, hemoglobin, 12 gm.; leucocytes, 8,400; prothrombin time, 14.8 seconds, or 55% normal; sulfobromophthalein, 4.25% at 30 minutes; total proteins, 11.2 gm. (albumin 6.6 gm. and globulin 4.6 gm.); cephalin flocculation, 3+ at 24 hours and 4+ at 48 hours; plasma sodium, 142 mEq. per liter; and urinary sodium, 60.8 mEq. in 1,000 ml. of urine in 24 hours. We are unable to explain the inordinately high serum albumin.

Case 9.—E. B., a white woman aged 59 years, was admitted to the Indianapolis General Hospital on June 22, 1951, with a diagnosis of "cardiac cirrhosis" because of the history of repeated "heart attacks" during the past six years. The patient stated that there was no excessive use of alcohol. There was a long history of ascites and portal congestion which was thought to be of cardiac origin. There had been at least three episodes of severe hematemesis, and x-ray examination disclosed esophageal varices. The patient contracted syphilis in 1909, and she received treatment for seven years. The liver was palpable approximately 1½ in. below the costal margin. There was a loud systolic and diastolic murmur heard over the cardiac apex, but repeated electrocardiograms were normal. The laboratory data were as follows: erythrocytes, 4,000,000; hemoglobin, 13.5 gm.; leucocytes, 6,000. Urinalysis showed a 1+ reaction for sugar (not constant), otherwise, results were normal. The total protein value is 7.8 gm. per 100 cc. (albumin 3 gm. and globulin 4.8 gm. per 100 cc.). The sulfobromophthalein test showed 42.5% retention at 30 minutes and 31.9% retention at 45 minutes; cephalin flocculation at 24 hours was 3+ and at 48 hours 4+; thymol turbidity, 22 units; colloidal red test result, 3+; serum bilirubin, 1.7 mg. per 100 cc.; prothrombin time, 46% of normal; alkalin phosphatase, 15.6 King-Armstrong units; plasma sodium, 193.3 mEq. per liter; urinary sodium, 37 mEq. in 24 hours in 1,830 ml. of urine; serologic reactions, 4+; renal blood flow, 663 cc. per minute; iodopyracet clearance, 398 cc. per minute; inulin clearance, 97 cc. per minute; filtration fraction, 0.24; Tm_D 43; renal blood flow/Tm_D 15.75. Exploration was done through a transverse incision on July 10, 1951. At this time the portal pressure was 272 mm. of citrate; and it fell to 200 mm. of citrate after the hepatic artery and the splenic arteries were doubly ligated. The patient continued to bleed from the esophageal varices postoperatively, and died of acute blood loss. Unfortunately, permission for autopsy was not obtained.

CASE 10.—K. J., a white woman, 44 years of age, was admitted to the Indianapolis General Hospital on April 23, 1951, complaining of ascites, bleeding hemorrhoids, hematemesis, and edema of the hands and feet. She stated that during the past five years she had consumed about 1½ pints of whiskey daily, and during the last year and a half the quantity was frequently twice that amount. The laboratory data were as follows: erythrocytes 3,510,000, hemoglobin 11.0 gm., leucocytes 15,000. Results of urinalysis were normal. The total protein value was 5.6 gm. per 100 cc. (albumin 2.5 gm. and globulin 3.1 gm.). The sulfobromophthalein retention was 69.2% at 30 minutes and 39.4% at 45 minutes; cephalin flocculation at 24 hours was doubtful and at 48 hours 3+; thymol turbidity was 3 Maclagan units, and the colloidal red test gave a negative reading. The serum bilirubin level was 2.12 mg. per 100 cc. The prothrombin time was 54% of normal; alkaline phosphatase, 9.3 King-Armstrong units; urinary sodium, 1.8 mEq. in 2,625 ml. of urine in 24 hours; blood Wassermann, negative; nonprotein nitrogen, 14 mg. per 100 cc.; renal blood flow, 741 cc. per minute; iodopyracet clearance, 526 cc. per minute; inulin clearance, 92 cc. per minute; filtration fraction, 0.175; Tm_D, 42; and renal blood flow/Tm_D, 17.8; sodium in diet, 1.5 gm., or 65.2 mEq.; and plasma sodium, 143.5 mEq. per liter. On July 12, at the time of surgery, 14,500 cc. of ascitic fluid was removed. The liver was small and nodular and the spleen greatly enlarged. Portal pressure was 538 mm. of citrate. The hepatic, splenic, and left gastric arteries were doubly ligated, and the spleen was removed. Portal pressure was again measured and found to be 222 mm. of citrate. Four weeks postoperatively the patient was greatly improved, her appetite was good, and there was a slight gain in weight; some ascitic fluid returned and was removed seven weeks postoperatively. It has not recurred. Vomiting and diarrhea were present for about two weeks after surgery. There has been no return of peripheral edema. Laboratory tests four weeks after surgery gave the following values: erythrocytes 3,900,000, hemoglobin 10 gm., leucocytes 5,500; results of urinalysis, normal; total proteins 7.5 gm. per 100 cc. (albumin 3.07 gm. and globulin 4.4 gm.). The sulfobromophthalein test showed 49% retention at 30 minutes and 38% retention at 45 minutes, and on Aug. 9, 1951, eight weeks postoperatively, the sulfobromophthalein test showed 34% retention at 30 minutes and 22% retention at 45 minutes; cephalin flocculation test at 24 hours was doubtful, and at 48 hours was 1+; thymol turbidity, 3 Maclagan units. The colloidal red test gave a 3+ reading. The serum bilirubin level is 3.65 mg. per 100 cc.; average urinary sodium, 163.4 mEq. in 1,800 ml. urine in 24 hours; plasma sodium, 140 mEq. per liter. The renal blood flow averages 1,035 cc. per minute; iodopyracet clearance, 673 cc. per minute; inulin clearance, 97 cc. per minute; filtration fraction, 0.145; Tm_D, 46.6; renal blood flow/Tm_D, 22.2; and plasma potassium, 4 mEq. There has been no recurrence of ascites or edema, and the patient states that she is in excellent health.

CASE 11.—C. T., a white man, was admitted to the General Hospital on July 8, 1951, complaining of weight loss of 60 lb. (27.2 kg.) in the last six months, chills and fever, weakness and anorexia. His occupation was that of a painter, but for five weeks prior to admission he had been bedfast because of extreme weakness. There was no history of excessive drinking. There has been no jaundice and only occasional vomiting. The liver was greatly enlarged and could be felt 3½ in. (8.9 cm.) below the costal margin; the spleen extended to the iliac crest. X-rays of the chest, gall bladder, and gastrointestinal tract were entirely normal. Bone marrow studies disclosed a general hyperplasia, but the peripheral blood showed anemia with thrombocytopenia. The electrocardiogram was normal. Spinal fluid examination was normal and all routine agglutination tests were negative. Other laboratory results were as follows: erythrocytes 2,820,000, hemoglobin 75.7 gm., leucocytes 3,100, blood thrombocytes (platelets) 50,000; results of urinalysis, normal; total protein values, 5.9 gm. per 100 cc. (albumin 2.5 gm. and globulin 3.4 gm.). The sulfobromophthalein retention was 10.7% at 30 minutes and 7.3% at 45 minutes; cephalin flocculation at 24 hours, 3+, and at 48 hours, 4+. Thymol turbidity was 10 Maclagan units, and the colloidal red test gave a 4+ reading. The serum bilirubin level was 3.63 mg. per 100 cc. The prothrombin time was 94% of normal. The alkaline phosphatase was 7.5 King-Armstrong units, and the blood Wassermann reaction, negative. A diagnosis of hypersplenism or Banti's syndrome with portal cirrhosis was made, and an exploratory operation was done on Aug. 25, 1951. There was a moderate amount of ascites measuring approximately 250 cc. The portal pressure, as measured in one of the omental veins, was 380 mm. of citrate. The spleen was greatly enlarged, and, because of the leucopenia, thrombo-

cytopenia, and anemia, splenectomy was done first. However, prior to the removal of the spleen the splenic artery was doubly ligated and divided. Next, the hepatic artery was triply ligated with chromic No. 1 silk. Portal pressure was again measured and found to be 348 mm. of citrate. A biopsy specimen of the liver showed advanced portal cirrhosis with hemochromatosis. The postoperative course was without complications. Laboratory studies two weeks after surgery revealed the following values: The platelets had risen to 125,000 per cubic mm., hemoglobin 12.5 gm., leucocytes 5,500. Results of urinalysis were normal. Other tests gave the following results: The clot retraction test, which showed no retraction before surgery, was not done postoperatively. Twenty days postoperatively the colloidal red test reading was 4+ in 24 hours; cephalin flocculation at 24 hours was 3+. The sulfobromophthalein test showed 7% retention in 45 minutes. The total protein value was 5.41 gm. per 100 cc. (albumin 2.85 gm. and globulin 2.56 gm.); and urinary sodium, 77 mEq. in 3,600 ml. of urine per 24 hours.

Case 12.—H. O., a white man 63 years of age, was admitted to the Indianapolis General Hospital on July 27, 1951. He had been a patient in and out of the Hospital for four or five years and his condition was diagnosed repeatedly as a chronic myocardial problem. About five years ago he noted weakness, lassitude, malaise, fatigue, and dyspnea. In August, 1950, the ascites increased rapidly and there was generalized anasarca. Frequent paracenteses were necessary and yielded 9,000 to 11,000 cc. of fluid every two to three weeks. His electrocardiogram suggested an old myocardial infarct, auricular fibrillation with possible ventricular conduction defect. The patient consumed large quantities of whiskey; however, he ate a well-balanced diet. He was jaundiced on three previous admissions. His laboratory studies were as follows: hemoglobin 13 gm., leucocytes 7,000. The urine contained a faint trace of albumin and occasional pus cell. The total protein value was 5.6 gm. per 100 cc. (albumin 4.6 gm. and globulin 1 gm.). The sulfobromophthalein test showed 14.4% retention at 30 minutes and 2.5% retention at 60 minutes; cephalin flocculation at 24 hours was 1+, and at 48 hours 1+; thymol turbidity, 4 Maclagan units; colloidal red test results, negative; serum bilirubin level, 0.974 mg. per 100 cc.; prothrombin time, 66% of normal; alkaline phosphatase, 3.9 King-Armstrong units; Wassermann reaction, negative; nonprotein nitrogen, 35 mg. per 100 cc.; plasma sodium, 139.3 mEq. per liter; urinary sodium, 1.1 mEq. in 1,000 ml. of urine per 24 hours; circulation time (ether) arm to lung 17 seconds, magnesium sulfate, arm to tongue, 25 seconds. The medical department thought that most of the patient's symptoms could be ascribed to a chronic myocardial degeneration. However, there was an element of doubt concerning the possibility of portal cirrhosis and therefore surgical exploration was carried out on Aug. 30, 1951. At this time approximately 12,000 cc. of slightly cloudy fluid was removed from the peritoneal cavity. The liver was definitely that of a nodular cirrhosis, and a biopsy specimen was taken. Portal pressure measured in an omental vein was 338 mm. of citrate before ligations and 310 mm. after ligations. Portal blood flow through the liver was estimated by injecting a 5% fluorescein sodium solution into the hepatic artery and then under ultraviolet light noting the time of its appearance in the portal vein. Fluorescein was detected about the portal vein within less than 10 seconds. At the end of about 25 seconds it was seen to disseminate throughout the general gastrointestinal tract and to collect in the portal vein area. This test was repeated three times and in each instance it was found that within 10 seconds after injection of the dye fluorescein could be easily seen around the small branches leading into the portal vein close to the liver. The appearance in the intestinal wall took 25 seconds.[13] The postoperative laboratory studies were as follows: hemoglobin, 10 gm.; leucocytes, 7,000; results of urinalysis, normal; urinary sodium, 8 mEq. in 660 ml. of urine per 24 hours. Three weeks postoperatively the sulfobromophthalein test showed 9.7% retention in 30 minutes and 2.7% retention in 60 minutes. The total protein value was 5 gm. (albumin 3.4 gm. and globulin 1.6 gm.). The patient made a surprisingly smooth recovery.

William L. Drake Jr. personally supervised many of the laboratory tests reported, and the Lilly Research Laboratories placed their facilities at our disposal during this study.

DISCUSSION

Dr. William A. Altemeier, Cincinnati: Dr. Berman's work is exceedingly interesting to all of us, and at his request, I am discussing seven cases in which operations were performed since April, 1951.

In our cases, we ligated both the hepatic and the splenic arteries 1 cm. from the celiac axis through an upper abdominal midline incision. Six patients survived the operation and one died. The death occurred 18 hours after operation and was caused by severe shock produced by an accidental tear in the splenic vein which measured 2 cm. in diameter. The hemorrhage was arrested, and the blood pressure was restored to 90 mm. of mercury, where it remained for 18 hours before a sudden terminal fall.

The results in the other six patients varied considerably. In the first patient, marked improvement in her general condition has followed the operative procedure. Her icteric index, which 10 days after operation rose to 60, has fallen to 8. The sulfobromophthalein liver function test has improved progressively, and the albumin-globulin ratio has been restored to normal limits. There has been considerable gain in weight. However, she has had two episodes of slight bleeding into the gastrointestinal tract, as manifested by tarry stools, but no drop in the red blood count.

A similar marked improvement occurred in the general condition of the second patient after operation. He had had 35 abdominal paracenteses prior to operation but has required none since. He has also gained weight, has had no recurrence of gastrointestinal bleeding, and is back at work.

The third patient has shown moderate improvement after ligation of the hepatic and splenic arteries. He has gained weight and feels better. One episode of slight bleeding occurred within one month after operation. His liver function has remained essentially the same. He has required no abdominal paracentesis.

A poor result was obtained in the fourth case. This patient survived operation, but an elevated temperature of 101 to 103 F. developed after the 15th postoperative day. Recurrent and progressive ascites appeared, and further evidence of deterioration of liver function has become manifested.

The fifth and sixth patients were operated on within the past three weeks, and each has survived the immediate postoperative period. Neither has required abdominal paracentesis as yet, even though the fifth patient had had 15 paracenteses preoperatively.

Our experiences have emphasized several points which we think are important in the management of these cases. In the first place, the procedure is not a simple one. The liver and spleen are usually greatly enlarged, and their size may hinder adequate exposure of the celiac axis The peritoneum is often thickened, particularly in the patients with ascites, and the collateral blood supply is marked. The shortest operative time in our series was two and three-quarter hours and the longest was seven hours. In this area the large retroperitoneal veins of the portal system have very friable walls. If they are torn or cut, hemostasis may be difficult to obtain, since the application of a hemostat or a silk ligature may cut through the wall of the vein. The use of the Bovie unit has been of considerable assistance in arresting the bleeding in the smaller peritoneal vessels.

The best results in our series occurred in those cases in which a definite fall in the portal pressure was measured after ligation of the hepatic and splenic arteries. This fall varied between 40 and 120 mm. of water in five cases, but in the other two the pressure did not fall. In one instance the pressure was actually higher than it was preoperatively.

Our anatomists have indicated that aberrant hepatic vessels may occur in approximately 40% of the cases. We are concerned about this and wonder if the presence of aberrant hepatic vessels may account for the absence of fall in portal pressure after ligation.

The most interesting aspect of the whole problem has been the demonstration of definite arteriovenous circulation between the hepatic artery and the portal vein in at least two of our cases. In all seven a definite palpable thrill was noted in the splenic and hepatic arteries. In two instances this thrill could be palpated in large collections of veins in the falciform ligament or in areas a distance from the celiac axis. Auscultation of the hepatic artery at the operating table with the use of a sterile stethoscope has indicated that two types of murmur may be present, either a single-phase systolic murmur or a double-phase systolic and diastolic murmur. The significance of this is not completely clear.

The progressive ascites developing in the fourth patient has been very disappointing. Presumably it has been caused by the development of focal liver necrosis, resulting from ligation of

the hepatic artery or from infection which has supervened. The latter is probably playing at least a minor role because of the development of fever and of leucocytosis, with white blood cells numbering from 22,000 to 27,000.

DR. W. KENNETH JENNINGS, Santa Barbara, Calif.: We were impressed with Dr. Berman's preliminary report concerning ligation of the hepatic artery proximal to its gastroduodenal branch and ligation of the splenic artery and in the past 10 months have done this operation on three patients. For each patient we followed the preoperative regimen recommended by Dr. Berman. Each patient had a history of a chronic ascites, and a diagnosis of advanced cirrhosis had been made by the medical department. For one patient, however, a 43-year-old woman, a diagnosis of biliary cirrhosis had been established one month before the ligation of the hepatic and splenic arteries. This woman died 48 hours after surgery, and at autopsy it was obvious that death was due to massive necrosis of the liver.

The other two patients were men, one a 48-year-old man with an 8-year history of cirrhosis of the liver. On this patient a paracentesis had been done eight years previously, after which he apparently had been successfully controlled by a strict dietary program and total abstinence from alcohol until three or four months before we saw him. He apparently entered a phase of liver failure in January, 1951. An abdominal paracentesis was done and 8 liters of fluid was recovered. He was then prepared for surgery, and at the time of operation approximately 1 liter of fluid was found in the abdominal cavity. In this case we were very much interested to find the liver reduced to approximately one-third normal size, and it was almost completely replaced by fibrotic tissue. The spleen was enormously enlarged, the lower pole reaching approximately the level of the brim of the pelvis. This man was dismissed from the hospital on his ninth postoperative day. He returned on the 12th postoperative day for a paracentesis, when approximately 2 liters of fluid was removed. His total protein level upon admission to the hospital preoperatively was 5.6. He has returned to his usual work as foreman of a road-construction gang. When last examined in November, 1951, approximately 10 months since his surgery, the spleen was reduced to approximately half the size seen at operation. He had no ascites and his total protein level was 6.5 gm.

The third patient was a 53-year-old man who entered our county hospital on June 7, with marked ascites. His icterus index was 14, total protein level 4.7 gm., and he was on the medical service for seven weeks during which period paracentesis was done five times. He was prepared for surgery and operated on July 26. After his surgery, paracentesis was necessary on two occasions. The first paracentesis was done two weeks following surgery, when approximately 1,000 cc. of fluid was removed, and again one month later, when 4,000 cc. was removed. His total protein level preoperatively was 5.7. In the last two months paracentesis has not been done, and when examined about two weeks ago he showed very definite clinical improvement. There was no evidence of ascites, and his total protein level was 7.4.

As a result of these experiences we cannot help feeling a certain enthusiasm for the operation, although we realize that a much more extensive clinical trial is necessary before it can be properly evaluated. However, I am sure you will agree that Dr. Berman is to be complimented for his courage in exploring this new concept which may prove a lifesaver and a more effective means of controlling this very discouraging problem.

I should like to corroborate Dr. Altemeier's statement that this is not a simple operative procedure.

DR. HENRY SWAN, Denver, Colo.: I talked to Dr. Berman about our two patients, and so I won't go into detail, but I should like to make a very brief comment with regard to the operative difficulty.

Before Dr. Berman presented his very careful experimental work and the beautiful study that he did on the first three patients, we had been doing the venous shunt operation. I believe that this operation too shouldn't be categorized as simple. It is an operation of considerable magnitude, involving a thoracolumbar incision, considerable blood loss, and a vascular anastomosis. In our hands, this procedure usually takes from four to seven hours. I think the ligation operation is much simpler technically, involving only an abdominal incision, less blood loss, and much less time than the other type of procedure.

It is clear that when all the branches of the celiac axis are ligated, the stomach and the liver are left in a sort of vascular hammock hanging between the phrenic communications above and the pancreaticoduodenal communications below. Normally, no other arterial channels exist. In these patients, however, it is clear that there must be additional circulation and that this collateral circulation is due to the portal cirrhosis. I believe Dr. Jennings thinks, and we agree, that in biliary cirrhosis this type of collateral circulation does not occur. We are confining ourselves completely to doing it on patients in whom liver biopsy has confirmed the presence of portal cirrhosis.

Of the two patients that we have had, the first one had recurrent ascites and the men on the medical service were at their wit's end. This patient's operation has been extremely satisfactory. It has now been five months since surgery. Within a month he had lost 30 lb. (13.6 kg.). This was all fluid, and he is now on a regular diet without salt control and has had no recurrent ascites, whereas before the operation he was having from 3 to 5 liters of fluid removed weekly.

The other patient had a low-grade chronic jaundice. We operated in this case because of bleeding esophageal varices, with minimal ascites. Since operation the ascites has increased and the patient still has the jaundice. Her result is not very satisfactory, and we take it then that we should agree with Dr. Berman that in the presence of evident jaundice the procedure may not be expected to give as good a result.

DR. ARNOLD JACKSON, Madison, Wis.: I believe that Dr. Berman's contribution is one of the outstanding ones that I have heard presented before the Association. It reminds me a good deal of classic papers by Kellogg Speed. I should like to report a case in which I was called in to see the patient as a consultant. This patient, a 40-year-old man, had had recurrent episodes of hemorrhage from bleeding esophageal varices during a period of five weeks. During this time he had suffered three attacks, and each time the hemoglobin fell to less than 30% and the red cell count to approximately 1,000,000. He had been given 51 blood transfusions, a total of 25,000 cc. each. Many methods of stopping the hemorrhages had been tried.

Dr. William Rienhoff of The Johns Hopkins Hospital first ligated the hepatic, splenic, and left gastric arteries in the human in 1947 and published in the June issue of the *Bulletin of the Johns Hopkins Hospital* a report of six cases, which he and others performed. My case makes a total of 11 cases now published. Last week Dr. Rienhoff said he had collected records of some 44 operations which have been performed. Although Dr. Rienhoff's first patient operated upon for this condition made a remarkable recovery, he did not feel justified to report it until he had successfully performed another operation this year. I knew my patient did not have cirrhosis. However, the esophageal varices were proved to be the cause of the bleeding, and this, in turn, was believed to be due to portal hypertension. The splenic and hepatic arteries were ligated close to the celiac axis with heavy linen ligatures. Last week I talked with Dr. Philip Thorek, and he said he had now operated upon 11 patients and that he ligated only the hepatic and splenic vessels and did so as close to the celiac axis as possible.

Following Dr. Rienhoff's plan, we gave the patient 400,000 units of penicillin and 1 gm. of streptomycin daily for five days before and after operation. Those who read the report from the Banting Institute in the October issue of *Surgery* will recall that 85% of the dogs died that were not given the antibiotics preoperatively, and 35% died even when the antibiotics were used. This work showed that these dogs died largely of liver abscess. There is no question but that the antibiotics are an important factor in preventing a septic hepatic necrosis.

My patient was operated upon under spinal anesthesia, and the procedure was not too difficult, but there was an annoying oozing in the pancreatic region. The patient had no reaction from the operation, which was less disturbing perhaps than a cholecystectomy, the patient being out of bed the day of operation. Within 10 days the red cell count was 4,500,000, and two weeks later he had gained 6 lb. (2.7 kg.) and felt well. He is progressing well to date. I have purposely omitted the laboratory data.

DR. JACOB K. BERMAN, Indianapolis, Ind.: [Moving picture]. When we began this study in 1947, I didn't think the results were going to be so encouraging. I should like to say a word about the venous thrill which Dr. Altemeier observed in the splenic vein in a patient with advanced portal cirrhosis. It is in all probability due to an arteriovenous shunt mechanism which is known to be present in the liver and spleen normally. We have used a 5% solution of sodium

fluorescein injected into the hepatic artery, and we were amazed to find that the appearance of this dye, as observed under ultraviolet light, could be detected in the hepatoduodenal ligament and small portal venous branches in less time than the arm to tongue circulation time. In one patient (H. O.) the arm to tongue circulation time was 25 seconds, whereas the hepatic artery to portal vein circulation time was about 15 seconds. Without a bypass which avoids the capillaries, the dye could not go through the hepatic and mesenteric capillary beds and return to the portal vein in a shorter period than it takes to go from the antecubital vein to the tongue. Therefore there must be a shunt mechanism in the liver and spleen. The former is both arteriovenous and venovenous. These cavernous hemangioma-like arteriovenous communications develop through the angiomatous transformation which occurs in portal cirrhosis and are probably, to some degree, exaggerations of normal shunts.

The first patient in the moving picture has had no paracenteses since the operation. This view shows the huge umbilical hernia and prominent abdominal veins prior to surgery. Some 18,000 cc. of ascitic fluid was being recovered at monthly intervals. He had been on medical management including cation exchange resins for two years.

The next patient showed greatly swollen extremities, and nine weeks after surgery the patient was able to be up and around and was not receiving any medication at all. His edema and ascites had disappeared.

I believe that we should restrict the use of this operation to portal cirrhosis until it can be more properly evaluated. We have limited its use at present to patients with an advanced type of portal cirrhosis. It is our desire to try it now on earlier cases. Ultimately the real value of the procedure will be more apparent; then we may find it useful in other types of cirrhosis.

DIAGNOSIS AND TREATMENT OF ADENOMATOUS POLYPS OF COLON

RUSSELL R. KLEIN, M.D.
AND
ROBERT A. SCARBOROUGH, M.D.
SAN FRANCISCO

THE PASSAGE of gross blood per rectum from a source above reach of a proctoscope is most commonly from a colonic neoplasm, either benign or malignant. Ninety-five per cent of benign lesions are precancerous adenomatous polyps,[1] whose discovery and eradication may prevent the development of carcinoma. Diagnosis of such lesions is dependent upon the judicious use of competent roentgenologic technique of barium-air contrast enema examination.

This report is based upon 100 patients in whom clinical investigation resulted in a roentgenologic diagnosis of one or more polyps of the colon. Patients with diffuse polyposis or with lesions suspected to be carcinoma are excluded. In all cases the diagnosis was verified by laparotomy and pathological examination. Diagnosis and definitive treatment will be discussed.

DIAGNOSIS

In each instance the principal presenting symptom was the passage of blood per rectum. In some patients there was a history of one or more acute gross hemorrhages, but more commonly bleeding was in small amounts, streaked on the surface of a formed stool, occasionally mixed with mucus. The primary diagnostic problem is differentiation between some local source of bleeding in the anal canal or rectum and a site of origin above reach of a proctoscope. Not infrequently the coexistence of hemorrhoids confuses the issue. Proctoscopy without preliminary bowel cleansing frequently will disclose evidence of blood in the lumen of the bowel quite obviously from a higher source. This was true in 35 of this series of 100 patients. In 25 patients proctoscopic examination revealed the presence of a single small nonulcerated sessile polyp. Such a sentinel polyp is highly suggestive of the existence of some other neoplastic lesion as the source of bleeding.

The four specific indications for roentgenological examination of the colon in the investigation of bleeding per rectum are (1) failure to demonstrate the source of bleeding by adequate anoscopic and proctoscopic examination, (2) evidence of blood in the lumen of the upper rectum on proctoscopic examination, (3) presence of a sentinel polyp, and (4) description by the patient of bleeding that suggests a higher source.

From the Department of Surgery, Stanford University School of Medicine, Stanford University.

1. Scarborough, R. A., and Klein, R. R.: Polypoid Lesions of Colon and Rectum, Am. J. Surg. **76**:723-727 (Dec.) 1948.

The accuracy of diagnosis of polyps of the colon rests with the roentgenologist. It is the responsibility of the surgeon to select the proper subjects for x-ray examination, to insist upon an adequate examination, and to request repeated examinations when the clinical evidence is indicative of the presence of an unidentified lesion. Not infrequently a second or third examination is required before a polyp is demonstrated. In one instance of persistent colonic bleeding, after three x-ray examinations and an exploratory laparotomy failed to reveal the source of bleeding, four more x-ray examinations were done before a small benign polyp was located and subsequently removed at a second laparotomy.

Certain features of x-ray examination should be emphasized.

1. Adequate preliminary preparation of the colon is imperative to avoid false shadows simulating polyps. At least 2 oz. (60 cc.) of castor oil taken 18 hours before examination, with subsequent restriction to a liquid diet without milk, is preferred.

2. An adequate number of spot films should be taken at suitable angles to unfold and visualize all overlapping loops of the bowel. Multiple films of the sigmoid colon should be made from various angles, since this is the most frequent site for colonic polyps and the most difficult area to examine.

3. There should be effective utilization of the air-contrast technique, employing horizontal ray examination with the patient in right prone, left prone and upright positions.

4. The presence of diverticula, particularly the presence of distortions resulting from diverticulitis, often masks a coexisting polyp. Frequently, the presence of gross blood in the stool is attributed to diverticulosis or to diverticulitis. Some authorities state that bleeding is commoner from this source than from carcinoma. In our experience, however, such bleeding has usually been found to be due to a coexisting neoplasm, often a single adenomatous polyp.

5. The presence of a polyp should be adequately demonstrated on the x-ray films before such diagnosis is accepted as indication for laparotomy. Unless a definite pedicle is visualized, confirmation of the apparent lesion by a second examination is advisable.

STATISTICAL DATA ON ONE HUNDRED PATIENTS

Colonic polyps were found to be 10% commoner in men than in women. The age incidence by decades was as follows:

	Decade								
	1st	2d	3d	4th	5th	6th	7th	8th	9th
Per cent	5	1	3	10	20	27	28	5	1

The location of polyps in the colon is shown in Figure 1.

A single polyp was found in 85 of 100 patients. Two polyps were found in 14 patients, and three polyps in 1 patient.

Microscopic evidence of malignancy was found in 23% of the tumors, and 77% were histologically benign.

PATHOLOGICAL DATA ON ONE HUNDRED PATIENTS

Pathological findings in this series of patients is of particular significance in the determination of appropriate treatment. Gross characteristics and microscopic

appearance by both frozen-section and permanent-section techniques were compared. A competent pathologist skilled in frozen-section preparation and interpretation is required for reliable diagnosis. A diagnosis of carcinoma was made only on evidence of actual invasion through the basement membrane or muscularis mucosae. Alterations in staining properties, increased frequency of mitotic figures, eccentricity of nuclei, or variations in the size of the glands were not accepted as evidence of malignancy. The 100 patients have been segregated into three groups.

Group I. Lesions Benign by Gross Appearance, Frozen-Section, and Permanent-Section Examination.—Of the 100 patients 77 belonged in this category. These polyps varied from 5 mm. to several centimeters in diameter, with an average diameter of 1 to 2 cm. In two instances unusual induration was viewed with suspicion, but frozen section examination demonstrated extensive old hemorrhage in a benign adenoma. Local excision of a polyp in this group is adequate treatment.

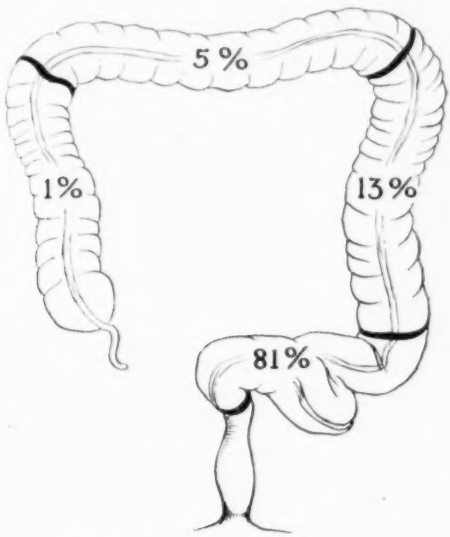


Fig. 1.—Location of polyps in colon.

Group II. Lesions Apparently Benign by Gross Appearance and Frozen Section, but in Permanent Sections Showing Small Focus of Malignancy in Otherwise Benign Adenoma.—In this group there were 12 patients. All had been treated by local excision of a pedunculated polyp several days before permanent-section examination disclosed a small focus of malignancy in an otherwise benign adenoma. No additional surgery was performed in these 12 patients. This decision was made on the basis of a calculated risk, the hazards of a second laparotomy for segmental resection appearing at least as great as the possibility of extension of carcinoma beyond the zone of previous excision. In this group of patients follow-up observation has continued for from 1 to 11 years. All 12 patients are alive and well.

Group III. Lesions Grossly Benign or Suspicious of Malignancy, with Demonstration of Malignancy by Frozen-Section Examination.—In this group there were 11 patients. In each instance radical segmental resection was immediately performed, as for any carcinoma in the same site. Subsequent examination of the resected specimens proved that 5 of the 11 already had regional lymph node metastases. In all five patients the malignant polyp had a well-

developed pedicle, with no microscopic evidence of any invasion of the pedicle by carcinoma (Fig. 2). Four of these five patients are still alive and well after from 2 to 12 years. One patient now has widespread intra-abdominal metastases, confirmed by recent laparotomy.

TREATMENT

The occurrence of one or more adenomatous polyps of the colon presents a number of argumentative problems in relation to treatment. There is general acceptance of the fact that such polyps are premalignant and should therefore be surgically removed. It is generally agreed that diffuse polyposis of the colon requires colectomy. There is considerable difference of opinion, however, as to the

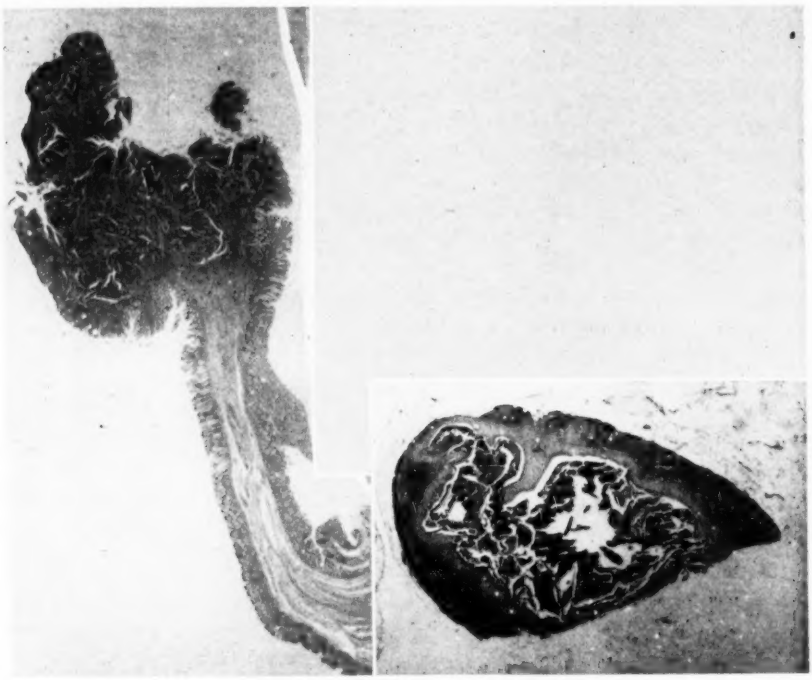


Fig. 2.—Malignant polyp without invasion of pedicle but with three regional lymph nodes containing metastases. (Insert shows high-power magnification of metastatic regional node. This node was 4 mm. in actual size.)

management of the problem when a single polyp, or even two or three polyps are found, both with and without microscopic evidence of malignancy. Colotomy and polypectomy, routine segmental resection, and even colectomy for a single benign polyp have been advocated. It is recognized that the presence of a single polyp may denote the possible presence of other small unrecognizable polyps. It is also recognized that in the patient with one polyp other polyps may later develop. These possibilities would be eliminated by colectomy, but such a radical solution to the problem seems unjustifiable. The routine employment of segmental resection does not exclude the possibility of subsequent development of a neoplasm in the remaining

colon. It is our opinion that such a procedure is unnecessary in the 77% of patients with a histologically benign adenomatous polyp, and that when employed for a malignant polyp, resection should be as radical as for any other carcinoma at the same site.

DEFINITIVE TREATMENT

The following plan of procedure appears justified on the basis of experience in 100 patients: Laparotomy is indicated when a diagnosis of colonic polyp has been made. Preliminary preparation should be instituted as for any proposed bowel resection. This includes mechanical cleansing of the colon with castor oil followed by a minimum period of three days with nonresidual diet and succinylsulfathiazole (sulfasuxidine®) or neomycin by mouth. Spinal anesthesia is preferred. Exploration is usually done through a lower left paramedian incision, since 81% of polyps are found in the sigmoid colon. The entire colon is carefully palpated by compression between the fingers for evidence of any polyps. This procedure is repeated several times. The possibility of the presence of additional unsuspected lesions must always be kept in mind. In 14 patients a second benign polyp was found in a separate segment of the colon, requiring a second colotomy incision. In one case three colotomy incisions were necessary, and three separate benign polyps were removed. In two instances large carcinomas were found respectively in the cecum and the sigmoid, in addition to the small benign polyp diagnosed by x-ray examination. A total of five barium enema examinations had failed to demonstrate either of these carcinomas. Such experience demonstrates the importance of routine exploration of the entire colon, as well as the desirability, on occasion, for surgical exploration for persistent colonic bleeding when x-ray examination has failed to establish a diagnosis.

If, after careful palpation of the entire colon, a single polyp is found, that polyp is expressed through a transverse colotomy incision made midway between the extremes of excursion of a movable lesion. In most instances the polyp can be readily expressed from the lumen of the bowel because of its pedicle. The base of the pedicle is clamped and transfixed with a plain No. 1 catgut suture prior to amputation. The polyp is examined carefully for evidence of induration or ulceration before it is submitted to the pathologist for immediate frozen-section examination. In our experience the presence of carcinoma in a grossly suspicious lesion has always been confirmed by frozen-section examination. When carcinoma is found on frozen section, whether or not the gross specimen appears benign, and whether or not there is a well-defined, soft pedicle, immediate radical resection is performed as for any carcinoma at the same site. The experience previously discussed of five patients in Group III with regional lymph node metastases would appear to be adequate justification for this procedure.

If the polyp appears benign on frozen-section examination, one further procedure is carried out before closure of the colotomy incision. A finger is inserted into the bowel lumen and the wall is carefully palpated both proximally and distally for evidence of any other polyps. By telescoping the bowel wall onto the examining finger, exploration can be effected for at least 6 to 8 in. (15 to 20 cm.) in either direction. An alternate procedure is the introduction of a sterile proctoscope through the colotomy incision for direct visual inspection of the mucosa.

RESULTS OF TREATMENT

There were no postoperative deaths. In one patient a postoperative obstruction requiring surgical intervention developed from a small bowel adhesion. In no patient yet has evidence of additional polyps of the colon developed. The majority of these patients were operated upon during the past six years, so no prediction can be made as to the possibility of future development of more polyps or carcinomas. Patients are examined and proctoscopy is done at least once a year. Periodic x-ray examination is not done or contemplated unless there should occur further evidence of bleeding or change in bowel habits.

SUMMARY

In 100 patients with adenomatous polyps of the colon, 81% of the polyps were in the sigmoid. In 85% there was present a single polyp. In 14% two polyps were found, and in 1% there were three polyps. In three out of four patients, or 77%, the lesions were benign, and simple polypectomy was performed. In 11% malignancy was proved by frozen-section examination, and radical segmental resection was done. In 5 of these 11 patients regional lymph node metastases had already occurred. In 12% small foci of carcinoma were found by permanent-section examination only in otherwise benign adenomas. Radical resection was not carried out in these 12 patients.

CONCLUSIONS

1. Any patient who has colonic bleeding or who is found to have a small sentinel polyp on proctoscopic examination should have a competent barium-air contrast enema examination.

2. Polyps that are benign in gross appearance and on frozen-section microscopic examination can be adequately removed by local excision.

3. When the presence of a malignant lesion is demonstrable by frozen-section examination, immediate radical resection is indicated.

4. There seems to be justification for being content with local excision of a polyp that appeared benign on frozen-section examination, when subsequent permanent sections reveal a small focus of malignancy.

DISCUSSION

DR. RALPH H. LOE, Seattle: Dr. Klein and Dr. Scarborough have had a very extensive personal experience in the management of polyps of the colon. As a result they have interested their pathologist in perfecting a frozen-section technique which in their hands has been largely satisfactory. Their decision to perform resection on the basis of penetration of the basement membrane rather than the base of the polyp by malignant cells appears to be a sound one. Unfortunately, most of us do not have pathologists who are willing to make this decision on the basis of a frozen section. Having seen Drs. Klein and Scarborough's frozen sections, I must agree that they are diagnostic.

Mention was made of the occasional use of the proctoscope at the operating table. I use a sigmoidoscope routinely for two reasons: In the first place, I have had difficulty in trying to locate the polyp by palpation or transillumination and have then introduced the scope through a sigmoidotomy opening for the purpose of finding it; in the second place, it is not unusual to find more than one polyp even though the x-ray study has shown only one. Since routine introduction of the sigmoidoscope, I have found an increasing number of multiple polyps.

The technique is simple. The bowel is prepared preoperatively with antibiotics. The sterile scope with obturator in place is easily manipulated to the splenic flexure, the obturator removed, and the bowel examined during withdrawal of the instrument. The bowel distal to the sigmoid-

otomy is examined in the same manner. Small sessile polyps are removed with a biting forceps and the base is cauterized. Pedunculated polyps are removed with electric snare. All tissues are examined for evidence of malignancy.

Drs. Klein and Scarborough have presented a sound basis for the management of polyps of the colon.

Dr. John V. Goode, Dallas, Texas: I should like to tell of a tragic experience at the time of fulguration of the base of one of these benign polyps. This experience came to Dr. Gray Carter, who is in the Veterans' Hospital outside of Dallas. Dr. Carter, during the course of the routine examination of one of his patients, found two small polyps at about 13 cm. above the dentate line. One of the polyps was visualized and removed uneventfully, but when the second polyp was removed and as its base was being fulgurated, an explosion took place and flame came out of the proctoscope. The patient said he felt considerable pain, but after he had been reassured, the proctoscope was reintroduced and nothing could be seen. Within two hours abdominal distention developed, and x-ray films made at the time showed free air in the peritoneal cavity. He was immediately brought back to the operating room, and three or four lacerations were found in the descending colon, each measuring about 8 cm. There was considerable bleeding in the mesentery of the colon. It was necessary to remove a portion of the descending colon. This patient is doing all right and is free of any complaints at the present time, but he and his surgeon have had a harrowing experience.

Dr. Stanley R. Maxeiner, Minneapolis: Perhaps some of you have been thinking since Dr. Goode made that remark, of the time when Dr. Percy years ago referred to a similar perforation of the gut following the use of diathermy current for cauterization. I think that report of probably some 10 or 15 years ago is worth looking up.

Dr. Mordant Peck, Denver: I am a little reluctant to discuss a subject which has been as extensively covered in the literature as has polyposis of the colon. However, I did not gain the impression, from what Dr. Klein has said, that he fully appreciates the importance of examination of the base of any polyp. It is well known that one cannot positively diagnose cancer in polyp by study of the tip of the polyp alone. Anyone who does not make a special point of taking off the base of the polyp in the bowel wall, and examining it very carefully, may leave behind a malignant process.

We have recently seen one such "dumbbell" tumor in which biopsy of the polyp on several different occasions was negative. It was not until adequate biopsy of the base of the polyp was obtained that a positive diagnosis could be made.

Dr. Russell R. Klein, San Francisco: I should like to thank the discussants for their comments. I have time to answer only one of the questions.

I do not think that the microscopic examination of the base of the pedicle of a pedunculated polyp at its attachment to the bowel wall is important. The pedicle is actually normal mucous membrane that is tented up by the pull of the adenomatous polyp in the bowel lumen. When invasive malignancy is present in the adenomatous polyp, spread may have extended to the lymph nodes with the pedicle completely uninvolved. In this case a radical bowel resection is required, including the mesentery, and the status of the pedicle, including its base, is relatively unimportant in making this decision.

TREATMENT OF EXTENSIVE PROLAPSE OF THE RECTUM IN AGED OR DEBILITATED PATIENTS

W. A. ALTEMEIER, M.D.
JEROME GIUSEFFI, M.D.
AND
PAUL HOXWORTH, M.D.
CINCINNATI

THE REPAIR of complete rectal prolapse in aged or debilitated patients requires the use of a surgical procedure which is followed by a high percentage of cure, a low mortality, and minimal morbidity. The large number of operations which have been suggested, tried, and often abandoned is indicative of the difficulties attending the management of rectal prolapse and of the frequency of unsatisfactory results. In general, the principles involved in the various operative procedures which have been advocated include the following: (1) resection of the protruding bowel; (2) reduction of the size of the anus and lower rectum; (3) plastic reconstruction or reinforcement of the perineal floor; (4) abdominal suspension, fixation, or both, of the prolapsed bowel, and (5) obliteration of the cul-de-sac.

The studies of Moschcowitz,[1] Todd,[2] Graham,[3] and Orr [4] have shown that a large rectal prolapse is essentially a sliding hernia of the anterior wall of the rectum through the anal canal (Fig. 1). Through a defect in the transversalis fascia and levator ani muscle, the cul-de-sac descends as a peritoneal or hernial sac, carrying with it the anterior wall of the rectum. With continued protrusion, the anal sphincter becomes relaxed, progressively stretched, and paralyzed.

Two chief approaches have been used for the operative repair of the lesion: abdominal and perineal. Moschcowitz used the former and emphasized the repair of the pelvic fascia and subsequent obliteration of the cul-de-sac. Unfortunately, the inherent difficulty in exposing the defect in the endopelvic fascia often impaired

From the Department of Surgery of the University of Cincinnati College of Medicine and Cincinnati General Hospital.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Nov. 30, 1951.

1. Moschcowitz, A. V.: The Pathogenesis, Anatomy, and Cure of Prolapse of the Rectum, Surg., Gynec. & Obst. **15**:7, 1912.

2. Todd, T. W.: Anatomical Considerations in the Rectal Prolapse of Infants, Ann. Surg. **71**:163, 1920.

3. Graham, R. R.: The Operative Repair of Massive Rectal Prolapse, Ann. Surg. **115**:1007, 1942.

4. Orr, T. G.: A Suspension Operation for Prolapse of the Rectum, Ann. Surg. **126**:833, 1947.

its closure. He attempted to close the separation of the levator ani muscles, but he found it to be so difficult that it had to be abandoned. Graham, in addition to the reconstruction of the endopelvic fascia and the obliteration of the cul-de-sac, was able to effect a repair of the levator ani musculature. In reporting these cases, he commented that this procedure was difficult technically and a formidable one for the patient. More recently, Orr reported an abdominal operation for complete prolapse, using fascial strips to suspend the rectosigmoid from the fascia over the promontory of the sacrum, along with obliteration of the cul-de-sac.

The perineal approach has been advocated by various surgeons, and it is interesting to note that it was also used in half of Moschcowitz's cases. As early as 1904, Miles [5] used a perineal procedure, designated as rectosigmoidectomy, which consisted primarily of intrasphincteric excision of the rectum and redundant sigmoid colon. He reported 31 cases in 1933, with only one recurrence and one death, which was not due directly to the operation. More recently, our attention was attracted to

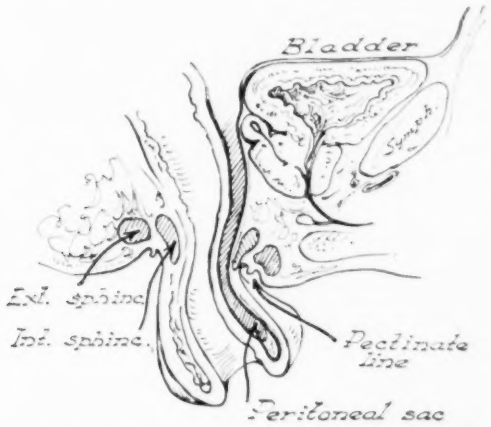


Fig. 1.—Sagittal section drawing showing various layers of rectal prolapse. Note herniation of peritoneal sac through anterior wall of rectum.

the excellent report of Dunphy,[6] who advocated a combined perineal and abdominal approach. Perineal repair was recommended first, followed at a later time by intra-abdominal repair of the pelvic fascia, obliteration of the cul-de-sac, and fixation of the colon to the left lateral wall.

Dunphy mentioned that only the perineal procedure was done on one aged patient and the intended abdominal approach was subsequently omitted when the patient appeared to be doing so well. Following this lead, we have used a modification of his perineal approach on nine patients who were considered to be either too physiologically aged or debilitated or otherwise unsuitable for an extensive abdominal or two-stage repair. A description of the operative technic employed and the results obtained follows.

5. Miles, W. E.: Rectosigmoidectomy as a Method of Treatment for Procidentia Recti, Proc. Roy. Soc. Med. **26**:1445, 1933.

6. Dunphy, J. E.: A Combined Perineal and Abdominal Operation for the Repair of Rectal Prolapse, Surg., Gynec. & Obst. **86**:493, 1948.

TREATMENT

Preoperative Treatment.—Each patient was hospitalized for at least seven days before operation during which he was given cleansing enemas twice daily, a liquid or low residue diet, and oral chemotherapy with succinylsulfathiazole (sultasuxidine®) or one of the antibiotic

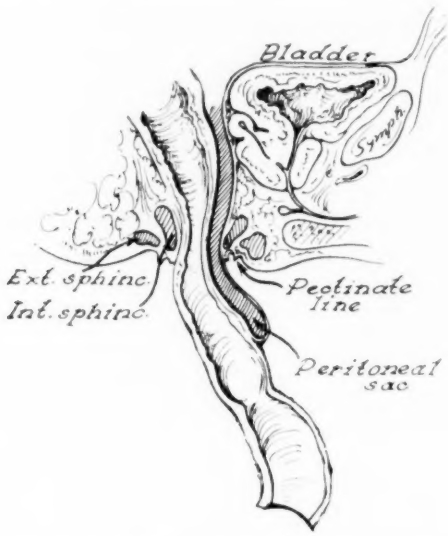


Fig. 2.—Diagram illustrating relationship of peritoneal sac to anterior wall of rectosigmoid after completion of circumferential incision and conversion of prolapse to single loop of redundant rectum and rectosigmoid.

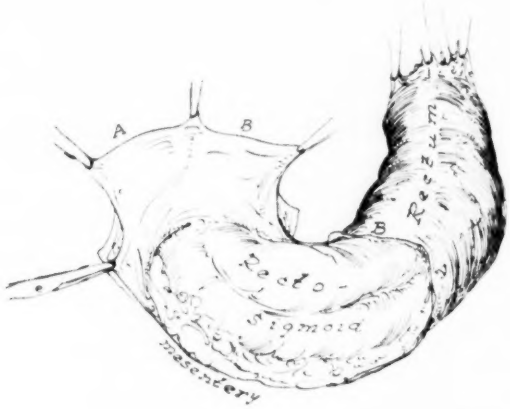


Fig. 3.—Drawing illustrating redundant loop of sigmoid, rectosigmoid, and mesentery which have been drawn through opened peritoneal sac.

agents, such as streptomycin, chloramphenicol (chloromycetin®), terramycin, or aureomycin. Local care of the prolapse included reduction of the mass, if possible, and hot moist applications to reduce any ulceration and infection which was present.

Operative Technic.—The operation was usually performed with the patient under continuous spinal anesthesia. An indwelling Foley bag catheter was used to keep the bladder empty throughout the operation and the first three to five days of the postoperative period. The patient was placed in the lithotomy position. The apex of the prolapsed rectal mass was grasped with Allis clamps and pulled downward. An incision was then made in the rectal mucosa about the circumference of the protruding mass about 3 mm. proximal to the pectinate line. Not more than a 3- or 4-mm. cuff of mucous membrane should be left in order to prevent undesirable protrusion of the anastomosis to be completed later. The incision was developed through the

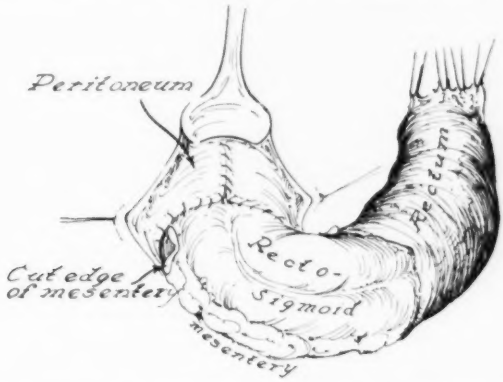


Fig. 4.—Closure of opening into peritoneal cavity has been effected at high level by continuous 00 chromic catgut sutures above site of bowel selected for resection.

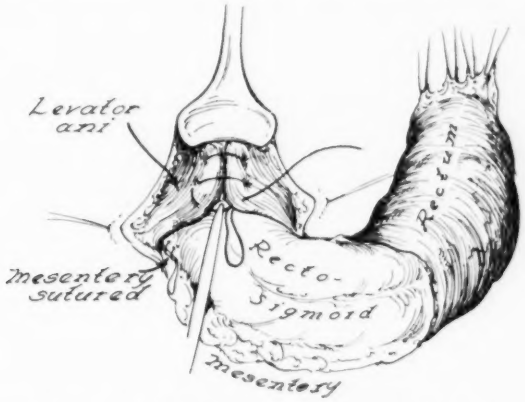


Fig. 5.—Obliteration of defect in levator ani muscles anteriorly by interrupted sutures of 0 chromic catgut.

mucosa and muscularis of the first layer of the bowel. This dissection area was very vascular, and all bleeding points were clamped and tied with 000 chromic surgical gut. The first layer of the bowel was then stripped distally from the underlying or inner loop (Fig. 2). The hernial sac was then located anteriorly and dissected free superiorly in its entire circumference as far as possible. The sac was opened and the peritoneal cavity explored. The sliding character of the hernia now became apparent because the posterior peritoneal layer of the sac was the serosa of the rectum. A large redundant loop of rectum and sigmoid colon with its attached

mesentery was visualized and easily delivered into the wound (Fig. 3). The site of resection of excess bowel was then selected so that the anastomosis could be effected later without tension or redundancy. The mesocolon and its vessels were divided at the selected site and the bowel prepared for resection and anastomosis. The peritoneal cavity was closed by suturing the peritoneum in a linear line anteriorly with a continuous 00 gut suture which was extended

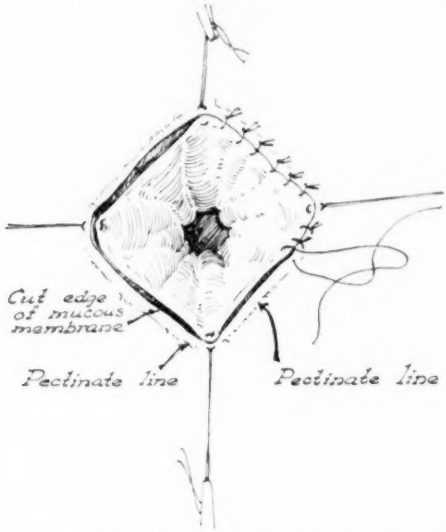


Fig. 6.—Final anastomosis of divided bowel to cuff of mucous membrane originally made at start of operation.

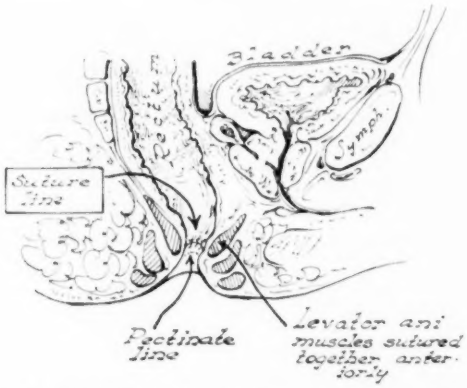


Fig. 7.—Drawing of sagittal section showing suture line at end of operation.

obliquely and laterally along one side of the bowel and its mesocolon. A similar running suture was used to close the remaining lateral peritoneal defect, producing an inverted Y-shaped closure (Fig. 4). The obliteration of the cul-de-sac was accomplished at a high level in this manner. The bowel was retracted posteriorly and the levator ani muscles were exposed on both sides. Their edges were then approximated anteriorly in the midline with three to four interruptured sutures of 0 chromic gut (Fig. 5). A strong muscular support was thus formed beneath the peritoneal closure, which completely eliminated the weakness in the pelvic floor.

With traction on the bowel, an anterior and posterior midline incision was made, dividing the bowel into two lateral halves up to the point previously prepared for resection. Two Mayo mattress sutures of 00 chromic gut were then used to unite the bowel and the mucous membrane 3 mm. from the pectinate line. The bowel was transected progressively and the anastomosis was completed with interrupted sutures of the same material until the entire circumference of bowel and anal mucosa had been united with careful mucosal apposition (Figs. 6 and 7). In the first patient, a Penrose drain was placed in the perirectal space, but this has not been done in any of the subsequent cases.

Postoperative Care.—All patients received therapy with penicillin in doses of 100,000 units intramuscularly every two or four hours, with or without 1 gm. of streptomycin. In two cases, chloramphenicol was used. A liquid diet was permitted initially, followed by a low residue diet after the second postoperative day. Liquid petrolatum was used daily to soften the stool. Early ambulation was started on the day following surgery.

RESULTS

A total of nine debilitated patients with rectal prolapse have had this operation. No transabdominal procedure was carried out in any case. The period of postoperative observation of 7 to 22 months is relatively short, however. In seven of the cases, the results were considered to be excellent, and in one, good. In the other, the first case in which operation was done, a partial recurrence has developed. There was no mortality.

CASE REPORTS

Case 1.—C. M., a senile 87-year-old white woman, was admitted to the hospital on Oct. 9, 1950, with a large rectal prolapse which she had had for several years and which had now grown so large as to cause her considerable difficulty in sitting and moving about. Examination revealed a feeble old woman with a large prolapsing rectal mass which obviously contained palpable loops of small bowel anteriorly. No sphincter tone could be elicited and the perineal hernia following reduction of the prolapse would easily admit a fist. Operation was performed with use of continuous spinal anesthesia on Nov. 25, 1950, and 18 in. (45.7 cm.) of bowel was resected. At the end of the procedure the line of anastomosis still protruded slightly. Her postoperative course was remarkably smooth. Follow-up at present reveals that a partial recurrence of the prolapse has occurred. It is attributed to the excess cuff of anal mucous membrane originally left, the incomplete excision of the redundant bowel at the time of surgery, and the inadequate closure of the defect in the levator ani muscles.

Case 2.—E. M., a 63-year-old white woman, was admitted to the hospital Jan. 10, 1951. The past history revealed that she had severe diabetes with advanced paresis. On examination, a large rectal prolapse, approximately 6 in. (15 cm.) in length, was found in addition to a large rectocele and obvious absence of any perineal body. No sphincter tone could be elicited. Cystometric study revealed normal dynamics, however. Operation was performed on Jan. 27, 1951, and 18 in. (45.7 cm.) of bowel was removed. Repair of the prolapse and perineorrhaphy under general anesthesia was included. The postoperative course was good, complicated only by a transient urinary tract infection. Recent follow-up reveals an excellent result with returning sphincter function.

Case 3.—V. P., a 67-year-old white woman, was admitted to the hospital on Dec. 30, 1950, with a rectal prolapse of eight years' duration and advanced cardiovascular disease. Examination showed a complete prolapse measuring 3½ in. (8.9 cm.), with superficial ulceration. Sphincter tone was fairly good. Operative repair was done under spinal anesthesia on Jan. 12, 1951, and 18 in. (45.7 cm.) of bowel was resected. Her postoperative course was uneventful, and she was discharged from the hospital on the tenth day. Follow-up examination in 11 months revealed an excellent result.

Case 4.—O. H., a 55-year-old white man, was admitted to the hospital on Dec. 3, 1950, with a 2½ in. (6.3 cm.) complete prolapse of two years' duration and hypertensive heart disease. Sphincter tone was fair. Operation was done under continuous spinal anesthesia on Dec. 12,

1950, and 10 in. (25.4 cm.) of bowel was removed. His postoperative course was smooth and he was discharged on Dec. 22, 1950. Recent examination shows an excellent result, with almost complete return of sphincter tone.

Case 5.—M. M., a 74-year-old white woman, was admitted to the hospital on Jan. 3, 1951, with a complete rectal prolapse of nine years' duration. Other diagnoses included cystitis and

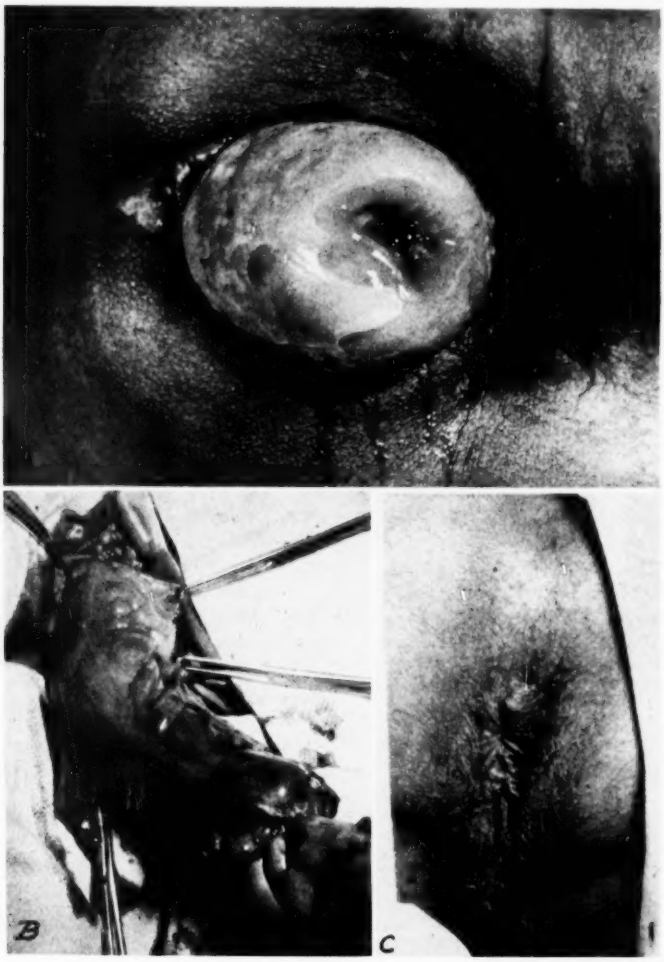


Fig. 8.—*A*, photograph of complete rectal prolapse in Case 7. *B*, view of redundant bowel and opening in peritoneum (compare with Fig. 3). *C*, appearance of anal region seven months after operation. There is no recurrence and sphincter tone is good.

hypertensive heart disease. Sphincter tone was poor. Operation was performed with continuous low spinal anesthesia on Jan. 14, 1951, and it included removal of 14 in. (35.6 cm.) of bowel. The postoperative course was uneventful, and the patient was discharged on Jan. 25, 1951. Progress examinations have shown no evidence of recurrence of the prolapse and fair return of sphincter function.

CASE 6.—A. S., a 70-year-old white man, was referred from the County Chronic Disease Hospital on April 18, 1951, because of a rectal prolapse present for two years. Examination revealed an incomplete rectal prolapse measuring 1½ in. (3.8 cm.) in length, with good sphincter tone. Operation was performed with spinal anesthesia on May 4, 1951. No sac was found, but the remainder of the procedure was effected as previously described. The postoperative course was uncomplicated, and he was discharged one week later. The patient died four months later, but until the time of his death, follow-up revealed an excellent result.

CASE 7.—C. W., a 65-year-old Negro man, was referred from the County Chronic Disease Hospital on June 18, 1951. The patient had had a right middle cerebral artery thrombosis in 1938 and had had progressive urinary difficulties because of urethral strictures which finally required suprapubic cystostomy in May, 1951. A large rectal prolapse of 8 in. (20.3 cm.) in length had been present for eight months. Anal sphincter tone was palpable. The mucous membrane was edematous and showed areas of contact ulceration. Operation was performed on July 31, 1951, with continuous spinal anesthesia, and 16 in. (40.6 cm.) of bowel was resected. The postoperative course was uneventful. Follow-up shows an excellent result, with good sphincter tone.

CASE 8.—J. H., a 57-year-old Negro man, was admitted to the hospital Nov. 9, 1950, with an incomplete rectal prolapse 1½ in. (3.8 cm.) long and consisting, on physical examination, entirely of mucous membrane. This had been present for four months. Sphincter tone was good. Operation was performed on Jan. 6, 1951, with general oxygen-ether anesthesia. As usual, perineal operation was performed, but no sac was identified. The postoperative course was uneventful. The patient has been lost to follow-up examination.

CASE 9.—O. H., a 49-year-old Negro man, was admitted to the hospital on Feb. 15, 1950, with a complete prolapse of the rectum 2 in. (5 cm.) in length and of two years' duration. He experienced considerable inconvenience and increasing difficulty in reducing the prolapse. Previously, he had had a thyroidectomy for hyperthyroidism on Jan. 7, 1950, and was under neuropsychiatric care for paranoid personality. Repair of the rectal prolapse was done on March 3, 1950, and the patient made a complete recovery. Five progress examinations made in the interim have shown good sphincter tone and no recurrence of the prolapse.

COMMENT

The problem of surgical cure of rectal prolapse is difficult under any circumstances. In the aged or debilitated patient, who is unable to withstand formidable surgery, the problem is greatly magnified. A perineal procedure which can be performed with little risk and which gives satisfactory results is desirable. The operation described has been tolerated very well by patients who were such poor operative risks that the hazard of surgery would have been significantly increased by extensive transabdominal procedures. The postoperative courses of these patients were unusually benign, the febrile response rarely exceeding 100 F. How much the preoperative and postoperative use of antibiotics contributed to this is not clear. In Case 2, in the presence of severe diabetes, antibiotic therapy must have been of benefit. However, Miles noted similar results in the prechemotherapeutic era.

The amount of bowel which was resected may seem to be excessive, and it is considerably more than that recommended by Dunphy. However, it appeared important to us to remove enough of the redundant bowel to permit obliteration of the cul-de-sac by closure of the peritoneum about the bowel at a much higher level than the base of the hernial sac.

The size of the defect in the anterior portion of the levator ani musculature was impressive, and we have attached particular significance to its closure. When the edges of the levators were approximated anteriorly by three or four sutures, a firm support was formed for a distance of 2 to 3 in. (5 to 7 cm.), immediately in

front of the bowel and below the closure of the peritoneum. This permitted adherence of the bowel to the levators and eliminated the pocket through which herniation might recur. It is important, however, not to constrict the lumen of the bowel by putting in too many sutures in the levators. We have been concerned with the possibility of cicatricial stenosis developing at the anastomotic site, but this complication has not occurred.

SUMMARY

The problem of surgical management of a rectal prolapse is greatly magnified in aged or debilitated patients. The extent or duration of operative procedures for this condition may be limited by the ability of the patient to withstand them. A perineal operation, similar to that used by Dunphy, has been described. It was used successfully in eight out of nine debilitated patients. Although it consisted of resection of the rectum and excessive bowel, good obliteration of the cul-de-sac, repair of the pelvic diaphragm, and satisfactory anastomosis, it has been well tolerated.

Although the procedure is recommended primarily for aged or debilitated persons with rectal prolapse, its use should be considered also in younger patients who are better surgical risks.

TWOFOLD EFFECT OF CORTICOTROPIN (ACTH) ON BLOOD CLOTTING AND ITS IMPLICATIONS IN SURGERY

A. B. McGRAW, M.D.
R. R. MARGULIS, M.D.
AND
B. E. BRUSH, M.D.
DETROIT

CONTRADICTORY reports can be found in the literature regarding the effect of corticotropin (ACTH) and cortisone on blood clotting.[1a, b, c] This paper will attempt to reconcile the discrepancies and to shed some light upon the problem involved. In addition, potential dangers in the clinical use of adrenal cortical hormones as regards the fluidity of the blood will be discussed.

The corticotropin used in this study was an LA-1 Standard lot, supplied through the courtesy of the Parke, Davis & Company Division of Clinical Investigation. The amounts of hormone used varied from 100 to 500 mg. per diem, given intramuscularly in divided, single 20 to 25 mg. doses. It was administered over periods of from one to eight days. Thirteen persons afflicted with thrombophlebitis or phlebothrombosis were treated in this preliminary study. Twelve received corticotropin, and one cortisone. Of those 13 patients, 8 had phlebothrombosis following various operative procedures. Five patients had thrombophlebitis; in one the condition was puerperal; in one, due to chemical irritation; one was traumatic, and two were spontaneous associated with varicosities.

The diagnosis of phlebothrombosis was made according to the criteria of pain, calf tenderness, Homan's sign, elevation of pulse and temperature, and edema of the affected extremity. In addition, the patients having thrombophlebitis showed redness and induration of the involved areas.

Before and during the administration of adrenocorticotropic hormone, the prothrombin time was followed by both Quick's [2] original method and the 1:8 dilution method of Shapiro.[3] In three patients protamine titrations [4] were done as an indirect

---

From the Henry Ford Hospital.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Nov. 30, 1951.

1. (*a*) Cosgriff, W. S.; Diefenbach, A. F., and Vogt, W.: Am. J. Med. **9**:752, 1950. (*b*) Smith, R. W.; Margulis, R. R.; Brennan, M. J., and Monto, R. W.: Science **112**: 295, 1950. (*c*) Fahey, J. L.: Proc. Soc. Exper. Biol. & Med. **77**: 491, 1951. (*d*) Margulis, R. R.: Proceedings of the Forum Sessions, American College of Surgeons, Philadelphia, W. B. Saunders Company, 1951, p. 507.

2. Quick, A. J.: Am. J. Clin. Path. **15**: 560, 1945.

3. Shapiro, S.; Sherwin, B.; Retish, M., and Campbell, H. A.: Proc. Soc. Exper. Biol. & Med. **50**: 85, 1942.

4. Allen, J. G.; Molder, P. V.; Elghammer, R. M.; Grosman, B. J.; McKean, C. L.; Sanderson, M. H.; Egner, W. M., and Crosbie, J.: J. Lab. & Clin. Med. **34**: 473, 1949.

TABLE 1.—*Signs, Symptoms, and Treatment in Patients with Phlebothrombosis*

			Signs and Symptoms				Treatment			
Name	Sex	Diagnosis, Phlebothrombosis Occurrence	Calf Tenderness	Swelling	Homan's Sign	Elevated Temperature	Hormone	Amount	Days	Relief
K. L.	F	4th postop. day	+	+	+	0	ACTH	125 mg.	2	4-6 hr.
L. M.	F	3d postop. day	+	..	0	±	ACTH	400 mg.	7	24 hr.
C. I.	F	6th postop. day	+	+	0	0	ACTH	120 mg.	3	24 hr.
S. J.	M	10th postop. day	+	±	+	+	ACTH	250 mg.	6	18 hr.
V. P.	F	17th postop. day	+	0	+	±	ACTH	200 mg.	4	2 hr.
K. P.	F	9th postop. day	+	0	0	0	ACTH	225 mg.	4	2 hr.
C. V.	F	6th postop. day	+	0	0	+	ACTH	505 mg.	8	18 hr.
W. E.	M	4th postop. day	+	0	+	0	ACTH	460 mg.	7	6 hr.

TABLE 2.—*Signs, Symptoms, and Treatment in Patients with Thrombophlebitis*

			Signs and Symptoms				Treatment			
Name	Sex	Diagnosis, Thrombophlebitis	Tenderness and Pain	Swelling and Redness	Homan's Sign	Elevated Temperature	Hormone	Amount	Days	Relief
S. G.	M	Recurrent, deep and superficial	+	+	0	0	ACTH	250 mg.	4	8 hr.
P. J.	M	Superficial, chemical	+	±	0	+	ACTH	100 mg.	1	4 hr.
O. C.	F	Phlegmasia alba dolens	+	+	+	+	ACTH	300 mg.	7	10 hr. edema 24 hr.
McT.	M	Traumatic, deep	+	+	±	+	ACTH	200 mg.	6	6 hr.
B. O.	F	Varicosities, superficial	+	+	0	0	Cortisone	450 mg.	3	18 hr.

TABLE 3.—*Changes in Eosinophile Counts and Prothrombin Times in Patients with Phlebothrombosis on ACTH Therapy*

		Eosinophile Count		Prothrombin (Seconds)			Prothrombin 1:8 Dilution		
Name	ACTH Mg.	Initial	On ACTH	Initial	On ACTH	After ACTH	Initial	On ACTH	After ACTH
K. L.	125	140	70	15-100%	21-56%	.....	..	..	..
L. M.	400	110	74	19-60%	23-48%	14-100%	..	48	28
C. I.	120	...	..	17-82%	20-62%	18-72%	28	48	42
S. J.	250	192	50	15-100%	22-52%	15-100%	..	52	32
C. V.	505	42	0	20-62%	44-17%	17-80%	..	45	36
W. E.	460	126	48	18-82%	25-42%	17-90%	35	92	42

TABLE 4.—*Changes in Eosinophile Counts and Prothrombin Times in Patients with Thrombophlebitis on ACTH Therapy*

			Eosinophile Count		Prothrombin (Seconds)			Prothrombin 1:8 Dilution		
Name	Diagnosis	ACTH Mg.	Initial	On ACTH	Initial	On ACTH	After ACTH	Initial	On ACTH	After ACTH
P. J.	Thrombophlebitis	100	210	90	20-68%	25-26%	17-82%	37	50	36
O. C.	Phlegmasia alba dolens	300	54	42	.....	No clot 5 min.	17-82%	..	115	34
McT.	Thrombophlebitis	200	179	69	23-54%	No clot 5 min.	14-100%	48	No clot 8 min.	35

way of measuring the heparin and heparin-like substances in the circulating blood. Eosinophile counts [5] were done to ascertain the responsiveness of the adrenal cortex to exogenous stimulation by corticotropin.

Clinically, all patients stated that their pain disappeared. Complete symptomatic relief was achieved in from 2 to 24 hours. Most of them also experienced mild elation and a feeling of well-being. Previous apprehension, irritability, or apathy

Fig. 1.—Primary thrombophlebitis before and four days following treatment.

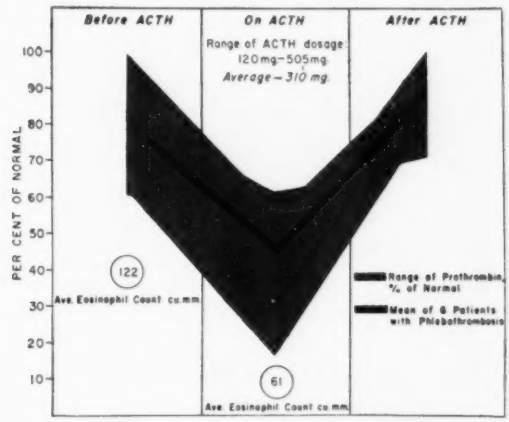


Fig. 2.—Results of corticotropin treatment.

disappeared usually before or with the pain. In five patients temperature which had been elevated returned to normal. The five patients with a positive Homan's sign lost that sign within the first 24 hours. In the one patient with puerperal thrombophlebitis (phlegmasia alba dolens), leg circumferences decreased by 7 in. (18 cm.) during the first 24 hours and the patient lost 5 lb. (2.3 kg.) in weight within the same period.

5. Forsham, P. H.; Thorn, G. W.; Prunty, F. T. G., and Hills, A. G.: J. Clin. Endocrinol. **8**:15, 1948.

Eosinophile counts were followed in eight patients. In six, the reduction of the eosinophiles was between 50 and 75%. In the remaining two cases, the reduction was less than 50% for the reason that the initial count was already depressed.

In all three patients in whom the protamine titration was followed, the initial value was low or normal and became significantly increased under corticotropin therapy. The initial value was usually doubled or nearly so (from 0.12 to 0.24 mg. per 100 cc.).

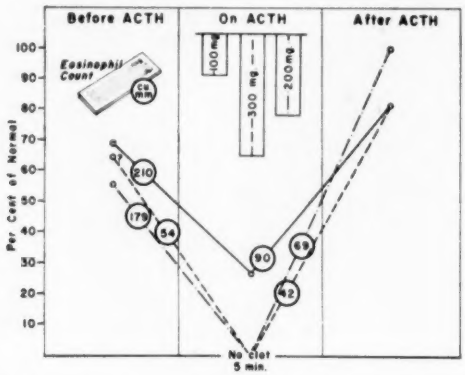


Fig. 3.—Prothrombin changes in three patients with thrombophlebitis.

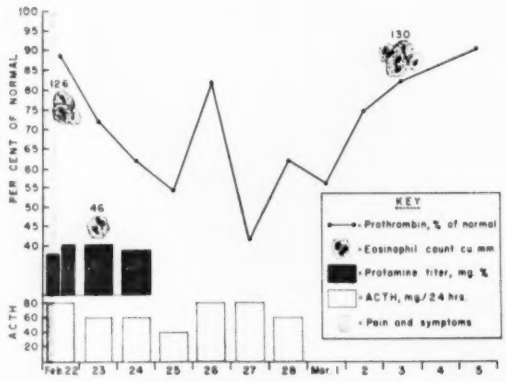


Fig. 4.—Postoperative phlebothrombosis, as evidenced in a 57-year-old man.

Prothrombin values were followed daily, and a significant reduction of the prothrombin level was noted in 9 tested cases. A parallel increase in the 1:8 dilution of the prothrombin time was seen in all of the tested cases.

Hypercoagulability of the blood has been mentioned in the literature as a condition brought about by the administration of corticotropin. We have recently observed one patient in whom this effect may have occurred. C. H., a white man, aged 63, was admitted 22 hours after the onset of severe abdominal pain originating in the left lower quadrant, increasing rapidly in intensity, and spreading over the

entire abdomen. On two previous occasions, this man had been hospitalized for recurring superficial lower extremity thrombophlebitis, and one year previously had had a right supracondylar amputation following the unsuccessful removal of an embolus from his right popliteal artery. He suffered from hypertension and generalized arteriosclerosis. On admission a tentative diagnosis of acute mesenteric thrombosis was made and proved at immediate operation. All but the proximal foot of the small intestine and the right half of the colon had to be resected. After operation the patient became dyspneic and cyanotic, with associated hypotensive oliguria. On his failure to respond to other measures, corticotropin was tried in unusually high doses (200 to 600 mg. daily for three days). He received 600 mg. in the first 24 hours, and his response was very good. His cyanosis disappeared, he became responsive, and his blood pressure rose to preoperative levels. On the sixth postoperative day, the use of corticotropin was suddenly stopped. That same day, six hours after the last dose of the drug, the blood pressure gradually fell to shock levels. Within the next 12 hours pulmonary edema developed and the patient died. At autopsy, besides further extension of the mesenteric thrombosis to include the entire celiac axis, extensive thromboses of the renal artery, of numerous pulmonary vessels, and of the portal veins were found. Also a septal infarction of recent origin was found in the heart.

It might well be argued that this man had a tendency toward intravascular clotting. Nevertheless, the time element was very suggestive that sudden withdrawal of massive doses of corticotropin may have facilitated and induced the almost generalized intravascular clotting.[6]

COMMENT

Material has been presented which suggests that corticotropin by inducing hyperheparinemia and hypoprothrombinemia favorably influences conditions in which intravascular clotting has taken place.[7] One case is also presented in which abrupt withdrawal of large doses of corticotropin may have induced or increased a state of hypercoagulability. To recapitulate briefly observations previously reported by one of us, 1[b,d] a single dose of 25 mg. of corticotropin, given to healthy adults resulted in a decrease of the eosinophile count of more than 50%. Concomitantly, prolongation of both diluted and undiluted prothrombin times was noted, also an increase in the protamine titer, indicating an increase in circulating heparin or a heparin-like substance.

When corticotropin was administered for a longer time, the protamine titer, after an initial rise, fell again and was accompanied by corresponding changes in the prothrombin time around the second and third day. Then another increase in circulating heparin occurred, exceeding the precorticotropin level but remaining below the initial peak. Occasionally greater variations were noted in the prothrombin levels under corticotropin administration.

Changes in the eosinophile count, protamine titration, and prothrombin time have been followed in patients undergoing and following surgery.[1d] The results correspond closely to those following the administration of corticotropin to nonsurgical

6. Our colleague Dr. D. E. Silagyi permitted us to report this case.

7. Hume, D. M., and Moore, F. D., in Proceedings of the Second ACTH Conference, edited by J. R. Mote, Philadelphia, The Blakiston Company, 1950, p. 289.

patients. By chance, daily protamine titrations were done on one patient in whom, after operation, phlebothrombosis developed. A fall in the heparin level occurred at the same time as the appearance of clinical symptoms.

All these observations, in addition to knowledge of the capacity of corticotropin to alter the inflammatory reaction, led us to attempt its use in the treatment of intravascular clotting with or without phlebitis, with the clinical improvement previously described.

The following working hypothesis was used as a premise in an attempt to explain the possibility that the same hormone may enhance two different processes—hypocoagulability, which may lead to bleeding, and hypercoagulability, which would favor the onset of intravascular clotting.

It has been shown that the mast cells, which are the carriers of heparin,[8] undergo morphological changes[9] and release, under stress, the circulating anticoagulant. Such changes would lead to a hyperheparinemia. It has been shown that in inflammation, acute infections, and stress, an increase occurs in the hyaluronidase inhibitor.[10] Later this inhibitor was identified with heparin.[11] Thus a dual confirmation of the previous observation of hyperheparinemia under corticotropin administration was made. Whenever the destruction of the mast cells exceeds their regeneration and the supply of heparin-carrier cells becomes exhausted, a hypoheparinemia will ensue. This can be expected after the administration of massive doses or prolonged administration of corticotropin. Another possibility that should be postulated is that when the corticotropin secretion becomes diminished, there fails to be liberated a sufficient amount of heparin from the mast cells. Such a condition again is created in a state of pituitary hypofunction which is brought about by a sudden withdrawal of the hormone after its prolonged administration or, between the fourth and fifth day after a surgical procedure.

Changes in the prothrombin time are harder to explain. It is known that heparin-induced changes reflect also upon the prothrombin. One also should at least consider the following possibility. Stress releases some epinephrine which, in turn, acts as a catalyst to alter the circulating profibrinolysin into the active enzyme fibrinolysin. The latter has the capacity of inactivating the prothrombin and fibrinogen[12] and lysing the created fibrin.

It has been noted by Cosgriff and others[13a] that under corticotropin therapy patients are sensitive to bishydroxycoumarin (dicumarol®) therapy. To this we can add an observation that there also was an increased reactivity to heparin administration which resulted in subcutaneous hematoma in one patient with phlebothrombosis who received both corticotropin and the usual amount of heparin.

From a review of the literature, it becomes evident that most of the reported cases of phlebothrombosis, including our own case, occurred after withdrawal of the hormone or after administration of massive doses.[13] This is in agreement with the above outlined hypothesis.

8. Jorpes, E.; Holmgren, H., and Wilander, O.: Ztschr. mikr.-anat. Forsch. **42:** 279, 1937.
9. Stuart, E. G.: Anat. Rec. **109:** 351, 1951.
10. Glick, D. J.: Bull. Mt. Sinai Hosp. **17:** 207, 1950.
11. Glick, D. J., and Bengt, S.: Science **113:** 388, 1951.
12. Loomis, E.: Personal communication to the authors.
13. Slocumb, C., in discussion on Hume & Moore,[7] p. 304. Moore, F. D.: Personal communication to the authors.

SUMMARY AND CONCLUSIONS

The twofold effect of corticotropin upon blood clotting is explained by suggesting a working hypothesis.

Twelve patients with phlebothrombosis and thrombophlebitis were treated with corticotropin and one with cortisone.

Subjective relief was obtained in all cases from 2 to 24 hours after the onset of the hormonal administration.

Objective changes, i. e., disappearance of Homan's sign, disappearance of edema and leg tenderness, and decrease of temperature elevation, were observed within the first 24 hours.

Elevation of the heparin level and decrease in the prothrombin level were found whenever tested.

No instance of pulmonary embolism was encountered in this series.

Despite the dramatic improvement in signs and symptoms and the favorable changes in the prothrombin times and heparin levels, no superiority over already established anticoagulants has been observed to warrant recommending the substitution of corticotropin and cortisone for them. Furthermore, the potential danger that corticotropin or cortisone may finally induce a state of hypercoagulability must be remembered.

DISCUSSION

DR. R. R. MARGULIS, Detroit, Mich.: I should just like to stress the point that the study which Dr. McGraw presented is by no means an invitation for the therapeutic use of corticotropin (ACTH) in phlebothrombosis. It was merely a continuation of our previous studies to see what effect those two hormones exert upon the blood clotting. We found previously that it affects a great deal the circulating anticoagulant, as measured by the protamine titration, the prothrombin time, and the prothrombin time with dilution. Whenever corticotropin was given intravenously, we were able to obtain more pronounced changes in the prothrombin time.

The use of corticotropin is of interest, not to place this hormone as a therapeutic agent in the treatment of phlebothrombosis, but as a factor which could shed light on the etiology of this disease.

BLOOD VOLUME STUDIES IN THORACIC SURGICAL OPERATIONS

COLONEL JAMES H. FORSEE
MEDICAL CORPS, UNITED STATES ARMY

SECOND LIEUTENANT CLAUDE H. SCHMIDT
MEDICAL SERVICE CORPS, UNITED STATES ARMY RESERVES

JOSEPH H. HOLMES, M.D.

EDWARD D. JENKINS, B.A.

D. M. HUEY, M.A.
DENVER
AND
COLONEL JOHN M. SALYER
MEDICAL CORPS, UNITED STATES ARMY

THE ESTIMATION of blood loss in surgical operations is of primary importance in determining the amount of blood replacement needed. While we know of no minutely accurate and practical method for solving this problem, the present study represents our approach to the problem in thoracic surgery.

Blood volume was measured with the Evans blue dye (T-1824) method based on Gregersen's 10-minute technique as modified by Huey and Holmes.[1] One hundred ninety-one patients undergoing thoracic surgical procedures were studied. Hematocrit determinations were made on heparinized blood with use of the Wintrobe tube (45 minutes at 2,400 rpm with a 19 cm. radius), and the plasma proteins were determined by the refractive index method of Neuhausen and Rioch.[2] In 120 operations on 94 patients, blood volume studies were made one to eight days before operation (80% within four days before operation) and within 24 hours after operation. Two weeks after operation, blood volume determinations were repeated on 33 of these patients. These studies were made during two periods,

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Nov. 30, 1951.

From the Surgical Service and Research Development Branch, Fitzsimons Army Hospital, and The Colorado Medical School.

1. (*a*) Gregersen, M. I.; Gibson, J. J., and Stead, E. A.: Plasma Volume Determination with Dyes: Errors in Colorimetry; The Use of the Blue Dye T-1824, Am. J. Physiol. **113:** 54-55, 1935. (*b*) Noble, R. P., and Gregersen, M. I.: Blood Volume in Clinical Shock: I. Mixing Time and Disappearance Rate of T-1824 in Normal Subjects and in Patients in Shock; Determination of Plasma Volume in Man from 10-Minute Sample, J. Clin. Invest. **25:**158-170, 1946. (*c*) Holmes, J. H., and Huey, D. M.: Blood Volume Studies at 5,280 Feet Altitude, Fed. Proc. **9:**64, 1950.

2. Neuhausen, B. S., and Rioch, D. M.: The Refractometric Determination of Serum Proteins, J. Biol. Chem. **55:**353-356, 1923.

June, 1949, to June, 1950, and April, 1951, to Nov., 1951, and, in general, were not evaluated until some time after completion of surgery. Thus, they were seldom utilized in determining blood replacement in any given patients.

At this altitude, 1 mile (1.6 kilometer) above sea level, the normal blood volume for men averaged 79.1 cc. per kilogram of body weight.[1c] The mean average preoperatively of 116 tuberculous patients at Fitzsimons Army Hospital was found to be 75.8 cc. per kilogram of body weight. The mean average for plasma volume was 39.7 cc. per kilogram of body weight. The extreme average showed a plasma volume of 43.8 cc. per kilogram and a blood volume of 80.4 cc. per kilogram of body weight.

Thoracic surgical procedures are, in general, characterized by long incisions that traverse large muscles, resection of ribs that causes considerable bleeding from the periosteum, prolonged anesthesia and operative time, manipulation often within

TABLE 1.—*Blood Volume Determined by Evans Blue Dye (T-1824)*

	Mean Averages		
	Normal Soldiers or Students	Non-tuberculous Patients	Tuberculous Patients
Number	87.0	20.0	116.0
Age (yr.)	27.0	31.0	30.0
Weight (kg.)	70.2	69.0	68.1
Blood volume (cc./kg. body wt.)	79.1	77.6	75.8
Plasma volume (cc./kg.)	41.0	39.9	39.7

TABLE 2.—*Blood Volume Change Twenty-Four Hours Following Thoracoplasty for Tuberculosis*

		Mean Averages		
Stage	No. of Patients	% Change in Blood Volume	Calculated Blood Loss, Cc.	Blood Transfusion, Cc.
First	48	—10.9	2,061	1,521
Second	23	—12.1	1,716	1,065
Third	11	— 3.9	1,201	1,014

serous cavities, and frequently a large extrafascial dead space. These favor the exudation of blood and fluid which we feel would favor further reduction in blood volume after surgery is completed, causing considerable change in the blood volume. In all operations in this study ether was used as the basic anesthetic agent.

Blood volume changes were studied in 82 patients suffering from pulmonary tuberculosis treated by extrapleural thoracoplasty. Forty-eight patients had a first stage (removal of upper three ribs); 23 had a second stage (removal of two or three ribs), 11 had a third stage (removal of two or three). The mean average blood volume changes, amount of blood transfused, and percentage change are tabulated in Table 2.

If the difference in the blood volume pre- and post-operatively exclusive of the amount of blood administered by transfusion indicates the total blood loss in these operations, our studies may suggest a considerably greater loss than generally recorded.[2a] It is significant that the studies being reported are based on values determined 24 hours after operation while other studies generally are based on

determinations made 30 minutes after operation.[3a] During this 24-hour interval the extrafascial space created by thoracoplasty is often filled by blood and fluid. Also blood in the pleural cavity cannot be considered part of the effective circulating blood volume and therefore is probably not measured by the blood volume determination. These factors and findings suggest that considerably more blood is needed for replacement than is generally employed.

We do not believe, however, that blood volume studies as determined by the Evans blue dye reflect exactness in ascertaining the amount of actively circulating blood. Stewart and Rourke emphasized this factor, stating, "Since this finding rests on the dye method of measurement, it suggests that the quantity of actively circulating blood is reduced by a shunting of blood into some compartment of the vascular system which the dye does not rapidly enter."[3b] They found 44% of 16 patients undergoing surgical operations (four thoracoplasties, four radical mastectomies, one subtotal gastric resection, two hysterectomies, one colporrhaphy, one herniorrhaphy, one pelvic laparotomy) had a reduction of 20% of the total blood volume time. This reduction was in most instances much greater than was accounted for by the measured loss caused by operation.[3b] The factors of etherization, surgical trauma, variations in blood volume determinations (the latter estimated as high as

TABLE 3.—*Blood Loss Determined by Dry Weighed Sponge Method*

Thoracoplasty for Tuberculosis Mean Averages			
Stage	No. of Patients	Blood Loss, Cc.	Blood Transfusion, Cc.
First	34	973	1,398
Second	10	755	1,050
Third	4	771	875

20%) are significant considerations.[4] In special studies in approximately 20 cases, no correlation was found between the blood volume changes and variations in venous pressure, and between the blood volume changes and measurement of blood coagulation by the Lee White method.

In another group of unselected patients studied, we found the calculated blood loss as determined by the Wangensteen dry weighed sponge method to be as given in Table 3.[5]

Blood volume determinations were made two weeks after operation on 27 patients treated by thoracoplasty. The variations noted are recorded in Table 4.

The group averaged a recovery of 97.7% to the normal preoperative blood volume level in the first-stage thoracoplasties, 90.8% in the second stage, and 99.3% in the third stage. These data, even though the number of patients studied is small, suggest, we believe, that the use of larger quantities of blood than that calculated

3. (*a*) Albritten, F. F., Jr.; Lipshutz, H.; Miller, B. J., and Gibbon, J. H., Jr.: Blood Volume Changes in Tuberculous Patients Treated by Thoracoplasty, J. Thoracic Surg. **19**:71-79, 1950. (*b*) Stewart, J. D., and Rourke, M.: Changes in Blood and Interstitial Fluid Resulting from Surgical Operation and Ether Anesthesia, J. Clin. Invest. **17**:413-416, 1938.

4. Evans, W. L., Jr.: Personal communication to the authors.

5. Baronofsky, I. D.; Treloar, A. E., and Wangensteen, O. H.: Blood Loss in Operations: A Statistical Comparison of Losses as Determined by the Gravimetric and Colorimetric Methods, Surgery **20**:761-769, 1946.

as lost at the time of operation by the weighed sponge method is desirable. It is probably a significant factor in the early recovery after operation and in preparation for subsequent stages of operations.

In a group of tuberculous patients treated by thoracoplasty the comparison of blood loss calculated by the weighed dry sponge method and blood volume (dye method) determination is recorded in Table 5. It should be remembered that the blood volume loss calculated from the dye method represents the changes 24 hours after operation, whereas the sponge method represents only operative loss, and the difference we believe emphasizes and justifies the giving of transfusions in excess of the estimated operative loss.

TABLE 4.—*Comparison of Blood Volume Determination on Same Patients by Evans Blue Dye (T-1824)*

Before and 14 Days After Thoracoplasty in Tuberculosis

Mean Averages

Stage	Cases	Blood Volume			Plasma Volume		
		Preop.	Postop. 14 Days	% Change	Preop.	Postop. 14 Days	% Change
First	19	4,842	4,730	—2.3	2,554	2,539	— 0.6
Second	3	4,932	4,479	—9.2	2,538	2,252	—11.3
Third	5	4,239	4,197	—0.97	2,268	2,201	— 3.0

TABLE 5.—*Comparison Between Blood Loss Determined by Weighed Sponge and Blood Volume (Dye) Method on the Same Patients*

Thoracoplasty for Tuberculosis

Mean Averages

Stage	No. of Patients	Blood Loss		Blood Transfusion, Cc.
		Blood Volume (Dye Method) Cc.	Weighed Sponge Method, Cc.	
First	12	1,832	971	1,333
Second	5	1,778	620	1,000
Third	4	1,045	647	875

TABLE 6.—*Operative Mortality*

Thoracoplasty for Tuberculosis

No. Operations	Deaths	% Mortality per Operation
1,085	3	0.26

The operative mortality, death within 60 days of operation, from Jan. 1, 1947 to July 1, 1951 in 1,085 consecutive stages of thoracoplasty operations in tuberculous patients, exclusive of tuberculous empyema, has been 0.26% (Table 6). The operative mortality per patient was 0.64%. Three patients died in a group of 467 on whom thoracoplasty was performed.

Pulmonary lobectomy is now so frequently performed that a knowledge of the blood loss at operation is much needed. The nature of the underlying pulmonary disease and the extent of adhesions between the lung and pleural surfaces markedly affect the amount of blood loss, and wide variations in blood volume determinations before and 24 hours after surgery are to be anticipated. Blood volume changes in 20

patients with pulmonary tuberculosis and 9 patients with nontuberculous bronchiectasis treated by lobectomy are recorded in Tables 7 and 8. A 3 to 5 rib thoracoplasty had preceded upper lobectomy in the tuberculous patients. Blood volume determinations made two weeks postoperatively on six unselected nontuberculous patients treated by lobectomy are recorded in Table 9 and show a mean value above the preoperative level. Individual ligation of the hilar structures (artery, vein, and bronchus) was accomplished in every instance. In a consecutive series of 478 adult patients treated at Fitzsimons Army Hospital by pulmonary lobectomy from all causes from March 15, 1946 to June 30, 1951 there were three deaths within 60 days, an operative mortality of 0.63% (Table 10).

The blood loss as determined by blood volume studies on three patients treated sponge method is recorded in Table 11 and here again is considerably below that determined by the dye method.

TABLE 7.—*Blood Volume Change Determined by Evans Blue Dye (T-1824)*

Lobectomy for Tuberculosis Mean Averages			
No. Patients	Blood Loss, Cc.	Blood Transfusion, Cc.	% Change
20	2,494	1,900	−11.0

TABLE 8.—*Blood Volume Change Determined by Evans Blue Dye (T-1824)*

Lobectomy for Bronchiectasis Mean Averages			
No. Patients	Blood Loss, Cc.	Blood Transfusion, Cc.	% Change
9	1,740	1,667	−3.3

TABLE 9.—*Comparison of Blood Volume Determination on Same Patients by Evans Blue Dye (T-1824)*

Before and 14 Days After Lobectomy for Nontuberculous Disease Mean Averages						
	Blood Volume			Plasma Volume		
No. of Cases	Preop.	Postop. 14 Days	% Change	Preop.	Postop. 14 Days	% Change
6	5,264	5,379	+2.1	2,739	2,938	+6.8

TABLE 10.—*Operative Mortality in Pulmonary Lobectomy for Bronchiectasis, Cyst, Tuberculosis, Tumor, etc.*

No. Patients	Deaths	Operative Mortality, %
478	3	0.63

TABLE 11.—*Blood Loss Determined by Dry Weighed Sponge Method*

Lobectomy for Tuberculosis Mean Averages		
No. Patients	Blood Loss, Cc.	Blood Transfusion, Cc.
11	1,349	2,090

Decortication of the lung may be a relatively simple procedure with slight to moderate blood loss or a very difficult one with marked blood loss. In general, tuberculosis probably gives this procedure its severest test relative to blood loss. The data referable to six patients is recorded in Table 12.

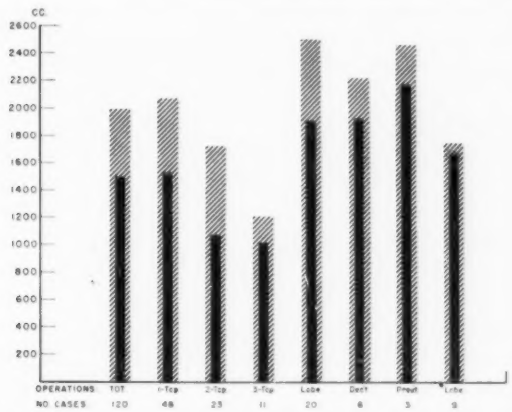
The blood loss as determined by blood volume studies on three patients treated by pneumonectomy for neoplastic disease is noted in Table 13.

TABLE 12.—*Blood Volume Change Determined by Evans Blue Dye (T-1824)*

Decortication for Tuberculosis Mean Averages			
No. Patients	Blood Loss, Cc.	Blood Transfusion, Cc.	% Change
6	2,217	1,917	−8.2

TABLE 13.—*Blood Volume Changes Determined by Evans Blue Dye (T-1824)*

Pneumonectomy for Neoplasm Mean Averages			
No. Patients	Blood Loss, Cc.	Blood Transfusion, Cc.	% Change
3	2,461	2,167	−4.6



Hatched and stippled columns indicate amount of blood loss. Black columns indicate amount of transfused blood. *Tcp.* indicates thoracoplasty; *lobe.*, lobectomy; *dec't.*, decortication, and *pneu't.*, pneumonectomy. *Bronchiectasis.

In our studies no reliable evidence was found to indicate that the red blood cell count, hemoglobin determination, or hematocrit values could be used to determine blood loss at operation or to ascertain the amount of blood replacement needed.

COMMENT

A summation of the pertinent data of these studies is depicted in the Chart. These data indicate an apparently greater blood loss in thoracic surgical operations than that generally recorded. The changes in blood volume values before operation and 24 hours after operation do not, it is believed, reflect exactness in estimating blood loss. Other factors, such as etherization, surgical trauma, probable failure

of the dye to enter rapidly all compartments of the vascular system, and the element of error in such determinations, account for an appreciable variation in blood volume values. This method is therefore not advised as a substitute for the valuable method of dry weighed sponge estimation of blood loss due to surgical operations. Our observation indicates that blood-volume estimations are approximately twice that calculated by the former method. It is our belief, based on these observations, that a more accurate practical replacement-therapy program in most thoracic surgical operations is feasible by employing the knowledge gained from both these methods. It is recommended that replacement by whole blood in most thoracic surgical operations exceed by approximately 35% to 50% that calculated as lost by the dry weighed sponge method. The usual minimal requirements, then, for a first-stage thoracoplasty should be approximately 1,500 cc.; 1,200 cc. for second-stage thoracoplasty, and 1,000 cc. for third stage. Pulmonary lobectomy would require approximately 1,500 to 2,000 cc. of whole blood replacement. Decortication would require, if technically difficult, 1,500 to 2,000 cc., and pneumonectomy would require 2,000 cc.

Emphasis is urged not to employ blood transfusion without its actually being needed. Its routine use for operations with little blood loss is not warranted.

SUMMARY AND CONCLUSION

The greater loss in blood volume observed 24 hours after thoracic surgery as compared with that determined at operation by the dry sponge method has been shown. This leads us to advise replacement of whole blood in most thoracic surgical procedures approximately 35% to 50% in excess of that calculated as lost by the dry weighed sponge method.

Fitzsimons General Hospital.

DIAPHRAGMATIC HERNIAS WITH VISCERAL COMPLICATIONS

DAVID H. WATKINS, M.D.
FRED R. HARPER, M.D.
AND
WILLIAM B. CONDON, M.D.
DENVER

VISCERAL complications associated with the presence of portions of the gastrointestinal tract as integral parts of diaphragmatic hernias are not common but may be of extreme gravity. We are presenting a series of five cases of diaphragmatic hernia with serious visceral complications. Two of these cases were caused by blunt trauma to the chest. In one case, hernia developed subsequent to a Smithwick type sympathectomy. In a hernia through the foramen of Morgagni symptoms developed only after postoperative distention consequent to a cup arthroplasty. In one case of an esophageal hiatal hernia, a secondary short esophagus and complete esophageal obstruction developed. The difficulties of diagnosis and surgical repair in these cases will be presented.

If the hernial content contains esophagus, stomach, duodenum, small intestine, or colon, the visceral accidents may be arranged in order of increasing seriousness as follows: obstruction, incarceration, and strangulation.

Incarceration may occur from the development of a discrepancy between the size of the content of the hernia and that of the hernial ring. This may be secondary to contraction of the scar in the case of a traumatic diaphragmatic hernia or stenosis due to increased muscle tonus.

Firm adhesions, which frequently are observed after traumatic injury of the diaphragm, can strangulate the misplaced viscera. In the case of the stomach and duodenum or colon, vascular compromise may be produced by axial torsion of the stomach, producing a volvulus secondary to tugging on the omentum at the greater curvature of the stomach. Torsion of the hernial sac in toto may lead to gastric vascular insufficiency.

The exciting incident precipitating incarceration may be the marked increase in intra-abdominal pressure produced by strenuous bodily activity, trauma, overeating, straining on defecation, postoperative distention, pregnancy, or parturition.

With incarceration of the stomach, vomiting is usually a prominent symptom, while hyperactive peristalsis or distention is lacking. Obstruction of the cardia or esophagus may be associated only with initial regurgitation. Small intestinal obstruction is associated with hyperperistalsis, but abdominal distention may be

From the Department of Surgery, University of Colorado School of Medicine.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Nov. 30, 1951.

lacking in those cases in which a large part of the stomach and intestinal tract is displaced into the chest and the abdomen may even be scaphoid. Intestinal colic is usually severe and may be associated with the presence of adventitious sounds in the chest.

REPORT OF CASES

The following cases are presented to demonstrate the difficulties of diagnosis and management of diaphragmatic hernias associated with visceral complications.

CASE 1.—A strong well-developed man, 31 years old, was injured in a head-on automobile accident. He was unconscious for 48 hours afterward. Three weeks later he came to our attention because of dyspnea, intermittent cramping abdominal pain, and pain in the left shoulder.

Examination showed dulness and absence of breath sounds over the left chest as high as the fourth interspace posteriorly. Borborygmi were present over this area. Roentgenologic examination following a barium meal showed the stomach and colon to be displaced into the left hemithorax; they extended as high as the third rib anteriorly (Fig. 1).

A diagnosis of traumatic left diaphragmatic hernia was made, and surgical intervention was advised. Following a left phrenic crush and the institution of transnasal intragastric suction, with the patient under intratracheal cyclopropane anesthesia, a left posterolateral incision was made through the seventh intercostal space. When the pleura was opened, the stomach, small intestine, colon, omentum, and left lobe of the liver were found in the thorax. No hernial sac was present. An interesting finding was a complete tear across the anterior mediastinum. Thus, both lungs were partially collapsed. The tear in the diaphragm was found to extend from a point 2 in. (5 cm.) to the left of the xiphoid process through the esophageal hiatus. After replacement of the abdominal viscera, the esophageal hiatus was reconstructed and the diaphragm repaired with silk mattress sutures. Additional interrupted silk sutures were used along the edges of the torn diaphragm. No attempt was made to close the mediastinal pleura. The lungs were fully reexpanded before closure of the thorax with drainage of the pleural space. The patient's postoperative course was uneventful. Roentgenograms taken subsequently showed no recurrence of the hernia.

This case represents an extensive traumatic rupture of the diaphragm and mediastinal pleura after severe blunt trauma. Transpleural repair was undertaken. Although bilateral pulmonary collapse was present to a degree during the operation, no untoward changes resulted.

The fear of disturbance of respiratory function by simultaneously having both pleural cavities open is nowadays not justified when anesthesia is properly administered through an endotracheal tube. Swan and others [1] have employed bilateral anterior intercostal thoracotomies in the exposure of the heart for the creation of auricular septal defects. An extensive exposure of the heart for pericardiectomy utilizing a sternal T-shaped incision has been employed by Forsee, Swan, Goyette, and Makel.[2]

The appearance of signs of intestinal obstruction made early operation mandatory. Preliminary crushing of the left phrenic nerve greatly facilitated the replacement of the abdominal viscera.

In our experience, when blunt trauma to the chest or abdomen has been severe enough to produce a rent in the diaphragm with immediate or subsequent develop-

1. Swan, H.; Maresh, G.; Johnson, M. E., and Warner, G.: The Experimental Creation and Closure of Auricular Septal Defects, J. Thoracic Surg. **20**:542-551 (Oct.) 1950.

2. Forsee, J. H.; Swan, H., II; Goyette, E. M., and Makel, H. P.: Calcification of the Pericardium, U. S. Armed Forces M. J. **2**:663-666 (April) 1951.

ment of a traumatic diaphragmatic hernia, the patient has always suffered loss of consciousness at the time of the original trauma.

CASE 2.—W. E., a 42-year-old white man, a schoolteacher, was admitted to the medical service on May 21, 1951, with the complaint of pain in the entire left chest, which radiated down the left arm. One day prior to admission he had experienced the sudden onset of pain

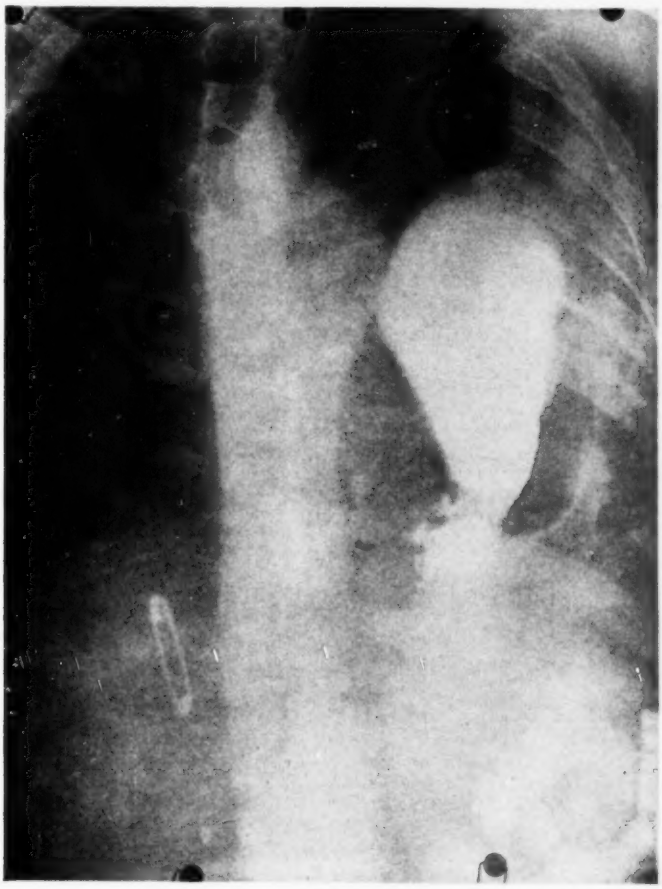


Fig. 1 (Case 1).—"Upside down" stomach showing inverted stomach filled with barium. Stomach has prolapsed through a rent in the diaphragm extending from the xiphoid through the esophageal hiatus.

in the chest without any premonitory symptoms. The pain had persisted constantly and had become unbearable. He was unable to take a deep breath, to cough, or to raise the left arm.

He had undergone a Smithwick[3] type of sympathectomy for hypertension one year previously.

3. Smithwick, R. H.: A Technic for Splanchnic Resection for Hypertension: Preliminary Report, Surgery **7**:1-8 (Jan.) 1940.

Examination revealed a well-nourished, acutely ill man. Blood pressure was 180/90, pulse rate 120, and temperature 102 F. Deep tenderness was present over the left chest. Dulness and absence of breath sounds were present over the lower half of the left chest.

Urinalysis showed 8 red blood cells per high power field. The total white blood cell count was 25,800, with 65% polymorphonuclear leucocytes. The electrocardiogram showed sinus tachycardia and left ventricular strain.

X-ray examination showed that the right lung was normal, the heart was enlarged, and the left diaphragm was not visualized. There was thought to be a dense pneumonic infiltration in the base, which was interpreted as a lobar pneumonia.

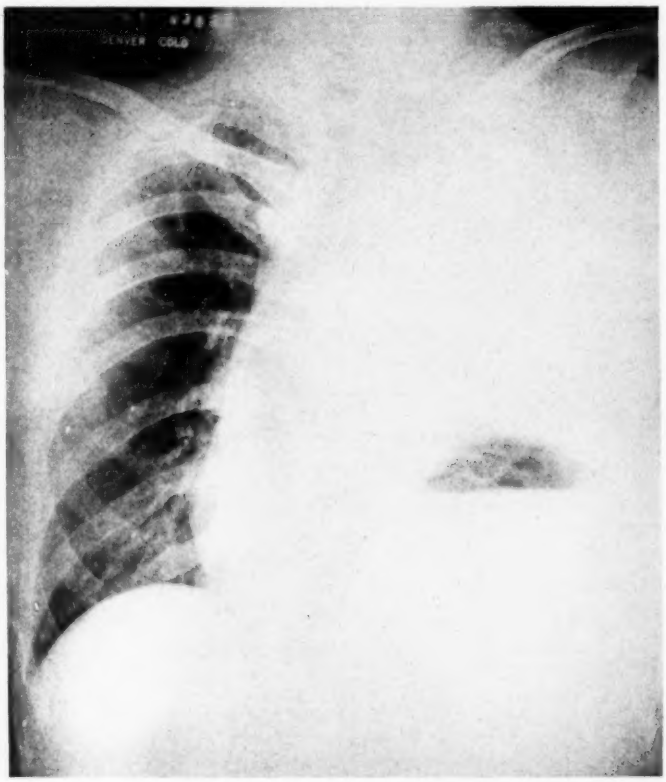


Fig. 2 (Case 2).—Left chest is entirely radiopaque except for the gas bubble in the lower third. Diagnosis was incorrectly thought to be massive pneumonia with pleural effusion.

The patient was treated with antibiotics and chemotherapy. Fever and pain persisted. On May 29, 1951, roentgenograms showed the left chest to be completely filled with fluid so that it was entirely radiopaque. The heart and mediastinum were displaced to the right (Fig. 2).

The patient was transferred to the surgical service on May 31, eight days after admission. A barium swallow, using a very thin suspension of barium, demonstrated the stomach to lie above the diaphragm in the left chest (Fig. 3). Indwelling nasogastric suction was instituted, and, after a short period of preoperative preparation, thoracotomy was carried out as an emergency. The preoperative diagnosis was strangulated traumatic diaphragmatic hernia.

With the patient under intratracheal general anesthesia, a left posterolateral incision was made through the bed of the eighth rib. The parietal pleura was opened; a large amount of gas and foul-smelling bloody exudate was evacuated. Both the visceral and the parietal pleural surfaces were very red and covered with fibrinous exudate. Beneath the lower lobe of the lung a portion of strangulated stomach, dilated, black, and with multiple perforations, was found above the diaphragm herniating through a 1 in. (2.5 cm.) opening. The opening was enlarged by another inch. The stomach was then elevated, and a small portion of gangrenous omentum was also found on the anterior wall of this mass. When the stomach was

Fig. 3 (Case 2).—After administration of barium, a portion of stomach (fundus) is seen to lie above the left diaphragm. Point of constriction of the stomach by the diaphragm is clearly shown.

mobilized sufficiently, healthy peritoneum was demonstrated, and the infradiaphragmatic portion of the stomach appeared in good condition. The necrotic portion of the stomach was removed without clamps. The vessels were ligated and the opening closed in three layers. The stomach was then dropped back into the abdomen. The diaphragmatic rent was closed by overlapping the edges, using interrupted silk sutures. The chest cavity was then evacuated of remaining fluid and exudate. An intercostal tube was placed in the ninth interspace.

Pathological examination of the resected, 15 cm. long portion of the stomach showed the walls to be soft and necrotic. The sodden mucosa was hemorrhagic and represented by a reddish-gray membrane. Multiple perforations were present.

The postoperative course was somewhat stormy. Gastrointestinal function was reestablished rather early, but the patient continued to have a spiking intermittent fever, with a maximum of 102 F. Serial roentgenograms showed the presence of a residual empyema. On July 2, 1951, a month after the thoracotomy, decortication of the lung was performed. The exudate on the parietal pleura was found to be ½ in. (1.3 cm.) thick, covering almost the entire chest wall. The visceral pleura was ¼ in. (0.64 cm.) thick. The thickened fibrinopurulent exudate was removed with moderate difficulty. In order to gain more adequate exposure, a section of the seventh rib was removed. At the completion of the procedure the lung expanded so that it filled the chest cavity completely. Two intercostal drains were placed, and the wound was closed in layers. Subsequent convalescence was prompt and uneventful.

This case demonstrated, as is true with many cases of traumatic diaphragmatic hernias, that the appearance of significant symptoms may be delayed. Diagnosis was difficult and was not firmly established until a barium swallow demonstrated a portion of the stomach to lie above the diaphragm.

Postoperative hiatal hernias have followed transabdominal vagotomy and gastric resection performed for peptic ulcer. Although diaphragmatic hernias, whether congenital, acquired, or traumatic, frequently contain stomach, instances of gastric perforation are rare.

CASE 3.—J. A. B., a 43-year-old white punch-press operator, was admitted to the surgical service after an automobile accident in which he had been thrown against the dashboard.

Examination revealed a forehead laceration which was bleeding freely. Blood pressure was 76/40 on admission but rapidly rose to 110/70 and remained at that level throughout his course. Crepitus was noticed in the right axillary line. Breath sounds were decreased over the entire right chest. Examination of the abdomen revealed a deep subcutaneous hematoma in the right flank. X-ray examination showed fractures of the first, second, third, fourth, and seventh right ribs posteriorly. There was a slight amount of fluid in the right pleural space and a nodular density 1 cm. in diameter in the left lower lung at the level of the fifth rib anteriorly.

The forehead laceration was sutured. The patient was treated with intercostal nerve blocks and aspiration of the hemothorax. The lung expanded, and he was discharged on the 10th hospital day. On admission he had had gross hematuria which persisted for 24 hours. Subsequent intravenous pyelograms revealed no abnormalities of the kidneys.

He returned one month later complaining of considerable chest pain. At that time there was dulness at the right base and friction rubs. Roentgenograms showed a rounded homogenous density, apparently arising from the midportion of the right dome of the diaphragm (Figs. 4 and 5). The exact nature of this shadow was not determined. Fluoroscopy with pneumoperitoneum gave the impression that this was loculated fluid rather than a diaphragmatic hernia.

Five weeks following the original accident, a right exploratory thoracotomy was undertaken. The incision was made through the bed of the sixth rib. A few adhesions fixed the lung to the diaphragm. These were freed, and a herniation of the liver was noted to be presenting through a 10 by 12 cm. rent in the centromedial portion of the right diaphragm. There was no hernial sac. The phrenic nerve was crushed in its lower portion. The projection of liver was freed from the diaphragm, and the defect in the diaphragm was closed in layers with interrupted silk sutures, imbricating the two leaves. Closed intercostal drainage was established through the ninth intercostal space. The chest wall was closed in layers. The postoperative convalescence was uneventful.

The development of the lesion in this patient within one month of the original blunt trauma to the right chest indicates how rapidly this lesion can develop. There was no associated post-traumatic increased intra-abdominal pressure, and the genesis of this lesion may be attributed to an initial unrecognized laceration of the diaphragm which failed to heal.

Wolfson and Goldman [4] in 1948 reported a strangulating hernia in which the mass of the liver protruded through the posteromedial portion of the right diaphragm. The patient had had attacks of nausea, vomiting, and epigastric pain periodically. The liver mass was constricted by about one-half as it traversed the fibrous ring of the diaphragm. Very interestingly, the attacks of pain and nausea disappeared after surgical repair and were attributed to intermittent attacks of strangulation.

Swan [5] observed a case of hernia through the left foramen of Morgagni which contained only liver. The heart and mediastinum were so displaced that cyanosis occurred. The initial diagnosis was congenital heart disease.

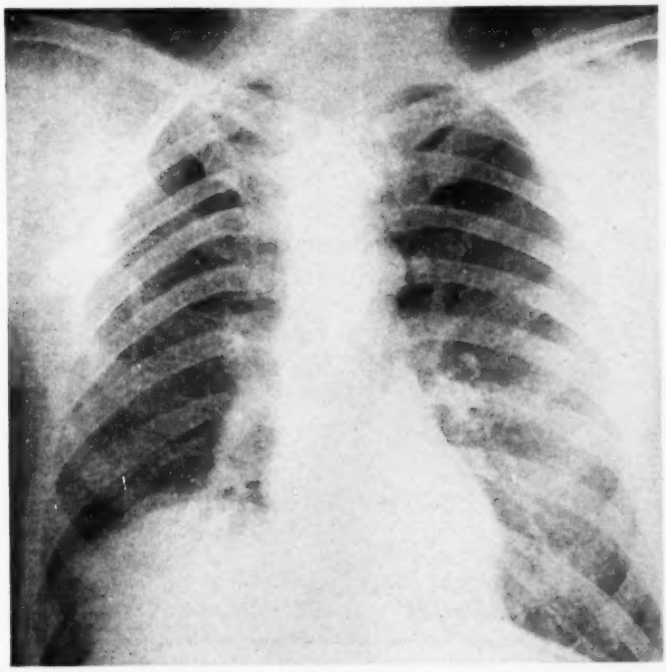


Fig. 4 (Case 3).—One month after original trauma a rounded homogenous density arising from midportion of right dome of diaphragm is seen.

CASE 4.—G. B., a 65-year-old white pensioner, was admitted to the surgical service with the complaint that he was unable to swallow solid food or liquids. He had been treated elsewhere from 1944 through 1946 for duodenal ulcer. His last gastrointestinal series showed deformity of the duodenal bulb. At that time he was advised to continue on a medical regimen with alkalis and antispasmodics, from which he received marked symptomatic relief. However, for the past three years he had suffered from almost continuous heartburn and substernal distress; this could be relieved only by drinking solutions of baking soda. Eight weeks before

4. Wolfson, S. A., and Goldman, A.: Strangulating Hernia of Liver, Surgery **24**:846-852 (Nov.) 1948.

5. Swan, H.: Personal communication to the authors.

admission he began having marked difficulty in swallowing solid food. This dysphagia rapidly worsened so that he was unable even to drink water at the time of admission.

Physical examination revealed evidences of moderate loss of weight. Laboratory examination demonstrated a hemoglobin level of 11.5 gm. per 100 cc.; white blood cell count of 6,500, with a normal differential distribution. Results of urinalysis were negative. The total protein level was 6.8 gm. per 100 cc. (albumin 4.0 gm. and globulin 2.8 gm.). The electrocardiogram was normal. Blood chemistry examinations showed nonprotein nitrogen 31 mg. per 100 cc.; chlorides 560 mg., sodium 300 mg. and potassium 18.3 mg.

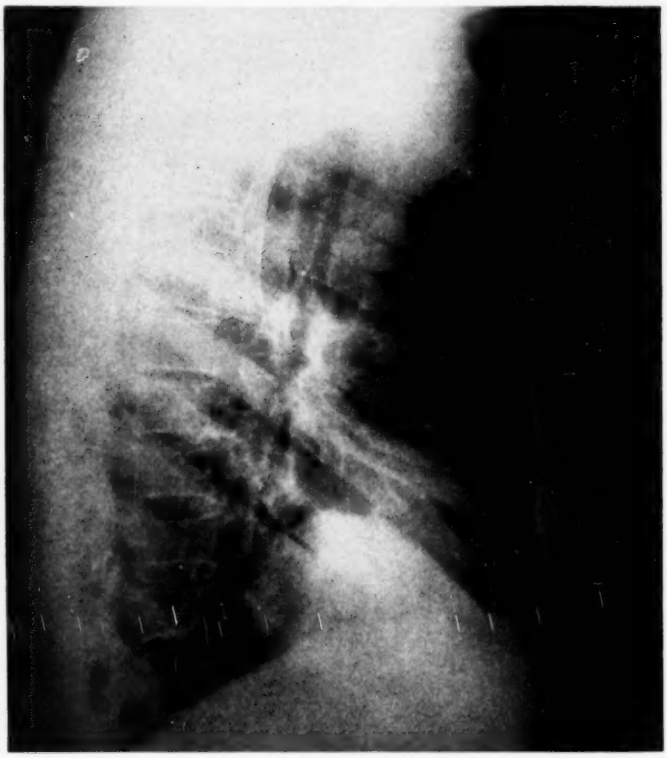


Fig. 5 (Case 3).—Lateral view one month after original trauma, showing homogenous density arising from midportion of right diaphragm.

X-ray of the esophagus showed that the barium column stopped 2 in. (5 cm.) above the normal position of the esophageal hiatus (Fig. 6). The portion of esophagus visualized just above the area of complete obstruction was seen to be smooth and somewhat dilated.

With use of topical cocaine anesthesia and intravenous secobarbital sodium (seconal® sodium) esophagoscopy was performed. The midthoracic esophagus was seen to be dilated and contained considerable foul-smelling fluid. In the lower thoracic esophagus the dilatation gradually narrowed to a complete obstruction, at the lower end of which was seen a mass of friable pinkish-yellow tissue which completely filled the lumen. Clinically, the impression was carcinoma. However, pathological examination of tissue removed for biopsy showed chronic inflammatory tissue without evidence of carcinoma.

Several attempts to have the patient swallow a silk thread were of no avail. Nutrition was maintained by parenteral means. It was felt that the patient's general condition presented

no contraindication to direct attack on the lesion and that performance of a jejunostomy for feeding purposes was unnecessary.

With the patient under satisfactory intratracheal general anesthesia, a left posterolateral incision was made through the bed of the eighth rib, and satisfactory exposure of the lower esophagus was obtained. Exploration revealed a hiatal hernia with approximately one-fourth of the stomach in the posterior mediastinum; there was marked thickening and narrowing of the lower third of the esophagus. No evidence of neoplasm was found. It was felt that this situation represented an esophageal hiatal hernia with esophagitis and peptic ulceration of the esophagus which had progressed to stricture formation and shortening so that a secondary short esophagus had resulted.

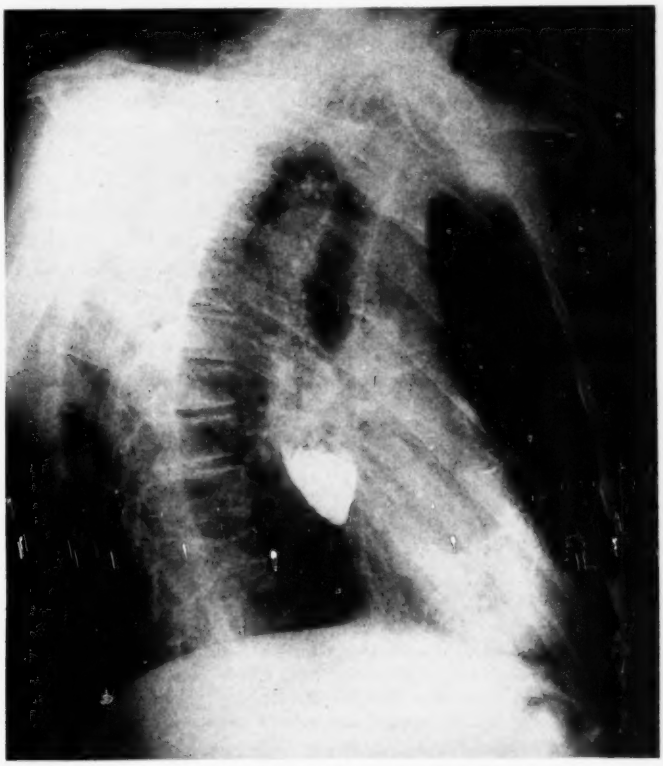


Fig. 6 (Case 4).—Roentgenograms of esophagus showing a thin barium suspension stopped 2 in. (5 cm.) above normal position of the esophageal hiatus. Note the even regular contour of the esophagus above the stricture.

The distal third of the esophagus was mobilized. Esophageal bougies, introduced through the mouth, even with external manual guidance and despite repeated attempts, could not be directed through the strictured area. Resection therefore was elected.

An incision was made in the diaphragm from the esophageal hiatus through the central tendon for exposure. Four inches (10 cm.) of distal esophagus and 2 in. (5 cm.) of proximal stomach were resected. The spleen was not removed. The line of resection of the stomach was closed with three layers of sutures. Anastomosis was made between the esophagus and the stomach at a level 1 in. (2.5 cm.) below the closed end of the stomach, utilizing an inner layer of fine surgical gut and external layers of interrupted surgical silk sutures. The stomach

was anchored to the parietal pleura with interrupted silk sutures; it was also sutured to the margins of the incised diaphragm. The diaphragmatic incision was closed snugly about the transplaced stomach.

Intercostal drainage was instituted through the ninth interspace and the chest wall closed in layers with interrupted sutures.

Pathological examination of the resected esophagus and stomach showed chronic ulcer of the esophagus with extensive fibrosis.

The postoperative course was uneventful, except for persistent left intercostal pain in the line of the incision. This responded to intercostal blocks.

The presenting complaint in this case was that of complete esophageal obstruction. Roentgenograms and esophagoscopy established the presence of a benign stricture of the esophagus impassable to bougies. Resection therefore was indicated. The symptomatic improvement in this case has been very satisfactory. The relationship between short esophagus and hiatal hernia has been debated for some time. The older idea was that in such cases the esophagus was congenitally short, and, as a result of this shortening, a partial thoracic stomach resulted. However, more recently the idea has been gaining ground that the majority of cases with diagnosis of short esophagus are primarily cases of hiatus insufficiency associated with spasm of the longitudinal muscle fibers of the esophagus. Herniation of the cardia into the mediastinum is associated with interference with the valve control and allows acid to flow into the esophagus. Esophagitis and peptic ulceration may follow this regurgitation.

Shortening of the esophagus by contraction, therefore, may result from stimulation, from an abnormality in the esophagus or upper abdomen, or from the irritation of regurgitated gastric content following herniation from some other cause. In some cases the shortening may become permanent consequent to fibrosis; this is a comparatively uncommon situation.

Allison,[6] in summarizing the current opinion, stated that the short esophagus is essentially an acquired condition due to defects in the diaphragm which allow a sliding hernia of the stomach.

Case 5.—H. M., a 65-year-old retired white man, was admitted to the orthopedic service because of pain in both hips, which had become especially severe during the previous four years. Locomotion was difficult, and he required a cane. He had had three previous nerve sections elsewhere because of pain associated with the osteoarthritis of the hips; these had given him no relief. He had had malaria while living in the Canal Zone in 1950. Intermittent attacks of convulsions had occurred since 1929; the diagnosis of idiopathic epilepsy had been made elsewhere. His last attack occurred six months previous to his hospital admission.

Physical examination showed a well-developed, rather obese man of 65, with pulse rate 80, and blood pressure 120/70. The pupils reacted poorly to light. The lung fields were normal throughout. A minimal systolic murmur was present at the apex. Painful motion of the hip joint with some restriction in excursion was present bilaterally. Reflexes were normal. Results of urinalysis were negative. Blood examination showed hemoglobin 14.7 gm. per 100 cc.; red cell count 4,740,000, and white cell count 6,000. The electrocardiogram showed left axis deviation; the S-T segments showed coving in Leads II and III. The T wave was inverted in Leads I, II, and III. Roentgenograms of the hips showed bilateral severe osteoarthritis.

On June 29, 1951, a vitallium® cup arthroplasty and right abductor tenotomy were performed on the right hip. The postoperative course was uneventful. On July 14, a left vitallium® cup arthroplasty was carried out.

6. Allison, P. R.: Peptic Ulcer of the Esophagus, Thorax **3**:20-42 (March) 1948.

On the 13th postoperative day following the second arthroplasty, upper abdominal distention, vomiting, and occasional right chest pain occurred. Copious amounts of dark drainage were obtained after placing an indwelling gastric suction tube. The patient was thought to have an acute dilatation of the stomach. Chest and abdominal roentgenograms taken on July 30, demonstrated distended loops of intestine in the right thorax (Figs. 7 and 8). The nausea, vomiting, and upper abdominal distention were much improved after the intragastric suction.

The patient was seen in consultation by the surgical service on Aug. 2. A diagnosis of incarcerated hernia through the foramen of Morgagni on the right was made.

Operation was performed on Aug. 3, through a right subcostal incision with the patient under intratracheal general anesthesia. When the abdomen was opened, the hernia through the foramen of Morgagni was demonstrated. The hernia contained one-half the stomach, the duodenum, the gall bladder, about 8 in. (20 cm.) of the colon, and some loops of small bowel. After the stomach was reduced, the colon and other viscera were easily replaced. The stomach was tremendously dilated, but there was no evidence of gangrene or necrosis. A gangrenous portion of greater omentum and a gangrenous piece of mesentery between the duodenum and

Fig. 7 (Case 5).—Lateral roentgenogram taken with patient lying flat in bed. Distended hollow viscera are shown in right hemithorax adjacent to anterior chest wall. Viscera extend through the foramen of Morgagni up to the clavicle.

the gall bladder were removed. Repair was accomplished by suturing the margin of the diaphragm to the posterior rectus sheath with interrupted sutures of surgical silk after excision of the hernial sac. A catheter was placed in the pleural cavity to aspirate air while the anesthetist inflated the lung with positive pressure. The abdominal incision was closed in layers with interrupted sutures.

This case represents incarceration of viscera in a foramen of Morgagni hernia precipitated by postoperative distention.

These hernias are essentially direct hernias occurring through an area of faulty attachment of the diaphragm to the sternum and costal cartilages. They consistently present a peritoneal sac. It is undeveloped at birth but occurs in most instances in later life because of increased intra-abdominal pressure acting on the congenitally defective diaphragm. In those cases which are characterized by the presence of hollow viscera in the hernia, symptoms of obstruction or strangulation are present.

COMMENT

Symptoms associated with traumatic and other types of diaphragmatic hernias depend on the structures involved in the hernia, on the degree of mechanical interference with the function of the herniated abdominal viscera, on interference with normal diaphragmatic motion, and on the degree of interference with the function of the intrathoracic viscera. If multiple viscera form the hernial content, particularly if the colon is involved, symptoms may be sudden and more dramatic in onset, often appearing shortly after the trauma is received.

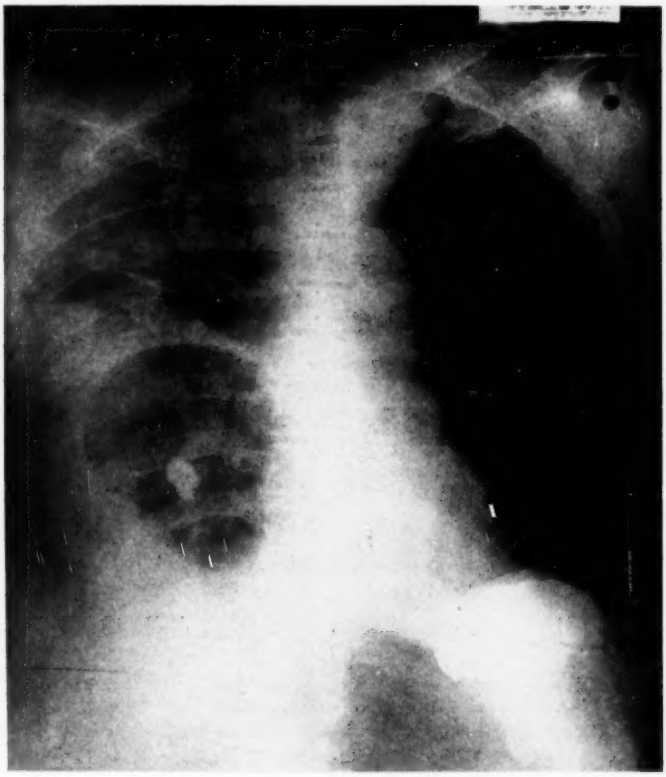


Fig. 8 (Case 5).—Gas bubble indicating presence of hollow viscus in right hemithorax. Small shadow of barium indicates a portion of stomach in the hernia.

Severe hemorrhage may occur from the incarceration and strangulation of the eviscerated organs. However, symptoms which might be attributed to interference with the function of the esophagus are prominent in the short esophagus cases.

Intra-abdominal pressure is an important factor in predisposing to the formation of diaphragmatic hernias as well as in the development of complications.

The investigation of any case of intestinal obstruction or vague gastrointestinal symptoms may properly utilize roentgenographic examination of the abdomen and chest to arrive at a correct diagnosis. While physical signs are often of extreme

value in indicating the true state of affairs, visual examination provides a more accurate and objective method of evaluation. Especially important is the investigation of the so-called high diaphragm, and particularly if this involves the left side, because frequently the thoracic position of the stomach may simulate a true elevated diaphragm. The administration of radiopaque media, such as iodized oil or thin barium suspension, by mouth may be of great value in determining the position of the stomach.

Intestinal obstruction, the consequence of an incarcerated or strangulated diaphragmatic hernia, is urgent indication for immediate surgical therapy. In cases of traumatic diaphragmatic hernia in which surgical therapy is delayed for any reason, the delay should be as short as possible because of the danger of intestinal obstruction. In addition to the hazards of obstruction, viscera which have prolapsed into the thoracic cavity lose their "right of residence" in the abdomen, as Harrington [7] has emphasized.

The approach to any surgical problem is always a matter of careful individualization and must always remain the choice of the individual surgeon. Ordinarily, however, we believe that in traumatic diaphragmatic hernias, or, more properly, in intrathoracic prolapse or evisceration of abdominal viscera, the expeditious approach is through the thorax. In these cases, interruption of the phrenic nerve may be a valuable preliminary procedure because it prevents muscle spasm and produces relaxation. It is also of value in the closure of large hernial openings in which which there has been marked loss of substance. In those cases in which phrenic interruption does not produce sufficient relaxation to allow repair of diaphragmatic defects, the diameter of the thorax can be narrowed by a small lower thoracoplasty where small segments of the 8th, 9th, and 10th ribs at the angles are resected.

SUMMARY

Diaphragmatic hernias may be responsible for serious complications that may involve either intrathoracic or abdominal viscera. The abdominal visceral complications are obstruction, incarceration, and strangulation.

Five cases of diaphragmatic hernias causing visceral complications have been presented. Three of these hernias were traumatic in origin, one was through the foramen of Morgagni, and one was through the esophageal hiatus. The complications included strangulation of the stomach, incarceration of the liver, stenosis of the esophagus, and gastrointestinal obstruction.

DISCUSSION

DR. GEORGE M. CURTIS, Columbus, Ohio: This excellent and well-prepared paper causes me to remark concerning one of the cases which Dr. Watkins presented, a case similar to one which we had in Columbus, Ohio.

It is with increasing frequency that we open up the chest for both thoracic and upper abdominal lesions. As a consequence, in certain cases the diaphragm is being opened more and more. We have had an experience similar to the case Dr. Watkins presented in that a subsequent hernia has come back through the opened diaphragm. Consequently, I should like to stress the point that in opening the diaphragm we should be especially careful regarding its closure.

---

7. Harrington, S. W.: Diagnosis and Treatment of Various Types of Diaphragmatic Hernia, Am. J. Surg. **50**:381-446 (Nov.) 1940.

DR. J. W. THOMPSON, St. Louis: There is one more category of unusual congenital diaphragmatic hernias that I think might be added to the list just presented. I refer to those in which there is a complication of pregnancy or puerperium.

Several years ago I reported the first patient successfully operated on who survived such a complication (Thompson, J. W., and Le Blanc, L. J.: Congenital Diaphragmatic Hernia, *Am. J. Surg.* **67**:123-130, 1945). She was a young woman who had gone into labor, her second labor, without ever having known that she had a congenital diaphragmatic hernia. Immediately post partum she presented symptoms of profound shock together with nausea and vomiting. A nasal tube was passed and on a chest x-ray plate the tube was demonstrated in the left chest cavity. An emergency operation was performed and it was found that all the abdominal organs except the liver had been forced up into the left thoracic cavity. They were successfully replaced in the abdomen, the hernia was repaired, and the patient made an uneventful recovery. I found after this that Diddle and Tidrick, at the University of Iowa, had reported this condition (Diddle, A. W., and Tidrick, R. T.: Diaphragmatic Hernia Associated with Pregnancy, *Am. J. Obst. & Gynec.* **41**:317, 1941). The second case in which a successful operation was completed was reported in September, 1950, by Pearson, Pillsbury, and McCallum, from Long Beach, Calif. (Pearson, S. C.; Pillsbury, S. G., and McCallum, M. W.: Strangulated Diaphragmatic Hernia Complicating Delivery, *J. A. M. A.* **44**:22-24, 1950). So I believe there is another category of unusual complications of diaphragmatic hernia which should be added to this list, namely, those complicating pregnancy.

I think it is well to remember that the complicating features of the diaphragmatic hernia may exist in pregnancy and puerperium. Of course, in the first stages of pregnancy, an operation might cause loss of the fetal life, but such complications certainly should be looked for in pregnant women and preparations made to take care of a possible emergency situation which may result in a fatality to both baby and mother if not promptly recognized and treated surgically.

DR. FRED R. HARPER, Denver: I was very much interested in the cases Dr. Watkins presented and also in Dr. Curtis's discussion. The point that was particularly brought out was that the diaphragm is not the rugged structure we are inclined to think it is.

In 1947 I presented before this Association an operation for a thoracoabdominal approach to the upper abdomen. The diaphragm is open in this approach; we have had no difficulty with this procedure, and are still continuing to use it. However, it is very important that the diaphragm be very carefully closed at the end of the operation because of the danger of diaphragmatic hernia. It has also been shown that the diaphragm can be eroded and herniations can occur after prolonged drainage of empyema with tubes. For these reasons, we should be careful in dealing with the diaphragm.

DR. WILLIAM B. CONDON, Denver: I should also like to stress the diagnosis of this condition. I believe that it can be occasionally rather obscure in both intra-abdominal and intrathoracic emergencies. In the second reported case in this series, the real diagnosis was not made until x-rays had thoroughly delineated the hernia—this, after only three days of hospitalization and treatment for a supposed lobar pneumonia. If we can only keep the diagnosis in mind, the repair and subsequent cure of the condition will naturally follow in the majority of instances.

SILENT NONTUBERCULOUS LESIONS OF CHEST DISCLOSED IN SURVEY X-RAY STUDIES

J. DEWEY BISGARD, M.D.
OMAHA

FOR SEVERAL years various public health agencies have been carrying on mass chest x-ray surveys to ferret out persons with silent or incipient pulmonary tuberculosis in the campaign to eradicate this communicable disease. As expected, this search has brought to light many silent nontuberculous lesions, and the incidence has far exceeded anticipation. A significant number of these lesions are proving to be malignant tumors, discovered at a time when the prospect of cure by resection is most favorable. A larger number are benign tumors and other surgical lesions.

It should be pointed out that there exists in the chest a unique situation for the detection of silent disease. The air in the inflated lungs provides an excellent x-ray contrast medium, against which the abnormal tissue densities produced by disease are discernible before the lesions have advanced beyond a silent or incipient stage. Also certain lesions which are not directly visible may reveal their presence by such secondary evidences as emphysema and atelectasis. This fact led various health-welfare-minded institutions and public health agencies to initiate mass chest x-ray studies. For many years routine chest x-ray examinations have been made of all military personnel and of the employees of many public and private institutions and of some industries.

In recent years there have been in progress in every state, city-wide, country-wide, or state-wide mass chest x-ray surveys. Through these various agencies the condition of the chests of a large segment of the population at a given time has been determined and recorded. Some of the data have been published, but since the surveys are primarily concerned with the detection of tuberculosis and since there are either no follow-up records or very incomplete ones, it is impossible to obtain accurate information, not only of the incidence of the various types of nontuberculous lesions but also of the over-all incidence.

Maxwell, Kerley, and Paxon [1] reported that in a series of 3,000,000 civilians examined in England during the three-year period from 1945 to 1948, abnormalities in 3,423 chests were detected. They classified the abnormalities in 1,225 cases as nontuberculous, 35% of the total. This group included, in addition to pulmonary and mediastinal lesions, malformations of the chest wall, rheumatic heart disease, congenital heart defects, and malformation of the great vessels. In 400 cases the

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Nov. 30, 1951.

1. Maxwell, J.; Kerley, P., and Paxon, T.: Discussion on Non-Tuberculous Conditions Revealed by Mass Radiography, Proc. Roy. Soc. Med. **42**:1039 (Dec.) 1949.

x-ray diagnosis (unconfirmed) was carcinoma of the lung. Novak and Waterman [2] reported an incidence of 3.3 % of cardiac, vascular, and nontuberculous pulmonary lesions in 14,998 well persons studied in a mass x-ray survey. The incidence of tuberculosis in the same group was 1.5 %.

In 100,000 consecutive x-ray examinations of Army separatees in 1945, Kinsey [3] found abnormalities in 169. The breakdown (x-ray diagnoses, unconfirmed) was as follows: tuberculosis 118, pneumonitis 24, bronchiectasis 11, mediastinal tumors 5, bullous emphysema 2, coccidiosis or cystic disease 3, silicosis 4, and Boeck's sarcoid 2. The much lower incidence of both tuberculous and nontuberculous lesions in the military compared with civilian groups is the result of selectivity through previous screening and of the lower over-all age level.

TABLE 1.—*Silent Nontuberculous Pulmonary Lesions (Including Tuberculoma)*

	Suspected	Confirmed	Error
1. Bronchogenic carcinoma	6	3	3
2. Bullous emphysema	3	..	..
3. Cystic disease	2	1	..
4. Virus or atypical pneumonia	2	..	..
5. Chronic nonspecific pneumonitis	..	2 (both diagnosed as carcinoma)	
6. Lymphoma	1	1	..
7. Bronchial adenoma	1	1	..
8. Metastatic carcinoma	2	1	..
9. Tuberculoma	9	6	..
10. Hamartoma	..	2	..

TABLE 2.—*Silent Nontuberculous Mediastinal Lesions*

	Suspected	Proved
1. Neurofibroma and neuroganglioma	5	5
2. Cysts (*a*) mesothelial—lymphangioma	..	2
(*b*) dermoid and keratoma	3	1
3. Lymphoma	1	1
4. Diaphragmatic hernia	3	3

Additional silent lesions reported by others [5]: bronchiectasis, silicosis, lung abscess, fungous infections, sarcoidosis, polycythemia vera, pulmonary arteriovenous fistula, histoplasmosis, eosinophilic pneumopathy (Löffler's), lipoma, chondroma, sarcoma, collagen disease (lupus, periarteritis nodosa).

Overholt [4] has reported some very informative statistics obtained through personal communications as follows:

In 10 city-wide surveys sponsored by the United States Public Health Service, 1,382 tumor suspects were found in 1,780,178 examinations, according to Bloomquist. This gave a yield of 80 per 100,000. The final breakdown, however, of the tumor suspects is not available. According to Hilbish, in Minneapolis, Seattle and Washington, the yield of primary malignancies of all types in the lung was about 10 per 100,000. In recent reports by Scamman on the

2. Novak, J. B., and Waterman T. L.: Results That Are Obtained in Mass X-Ray Survey, Illinois M. J. **97**:262 (May) 1950.

3. Kinsey, F. R.: Pathologic Chest Findings in 100,000 Consecutive Examinations of Army Separatees, Bull. U. S. Army M. Dept. **9**:1051 (Dec.) 1949.

4. Overholt, R. H.: The Most Detectable Internal Cancer, South. M. J. **44**:493 (June) 1951.

5. Clark, D.; Tempel, C. W., and Allen, K. D. A.: Diagnosis of Pulmonary Lesions Discovered by Mass Roentgenographic Survey, J. A. M. A. **143**:943 (July 15) 1950.

survey in Boston (the Fall of 1949), 398 (75 per 100,000) were read as tumor suspects out of 536,012 satisfactory films. At the time of his report 343 of these had been followed and 58 proved to have cancer, a rate of 15.8 per 100,000.

From his personal experience, Overholt reported 58 tumors in a group of 162 cases explored from a series of 393 survey lesions. Thirty-nine of the tumors were malignant, 19 were benign, 28 were cystic, and 17 were classified as others.

In Nebraska a state-wide survey has been in progress six years, and during this period chest films have been made of 548,779 persons. Evidence of abnormality was found in 15,188, or 2.9%. The lesions of approximately 5,000, or one-third of those with abnormal chests, were reported as probably tuberculous. Lesions in the remaining two-thirds were diagnosed as nontuberculous with no further classification. In 42 of these nontuberculous survey cases with silent lesions (including 9 tuberculomas) treatment has been carried out by me during the three-year period, July 1, 1948, to July 1, 1951. Exploratory thoracotomy with resection was carried out in 29 cases. In each instance, the diagnosis was established by histological examination of the resected or biopsy specimen. In 13 cases surgical intervention was not indicated, and the roentgenographic diagnosis in each instance was accepted as obvious. In six cases exploration was done with a preoperative diagnosis of bronchogenic carcinoma, and resections were carried out in five. In three cases the diagnosis of carcinoma was confirmed, and in two the lesions proved to be chronic nonspecific organizing pneumonitis. In the remaining case the lesion was inactive healed tuberculosis. A classification of the series is given in the tables.

SUMMARY

Attention is directed to a very important by-product of the mass x-ray survey studies which are in progress throughout the country. It is likely that the benefits which will accrue to the nontuberculous survey subject will equal or exceed those of the tuberculous subjects for whom the surveys are primarily conducted. It provides an excellent opportunity to discover bronchogenic carcinoma in some individuals at a very early stage in its development. In no other internal concealed organ is there afforded an equal opportunity for making an early diagnosis of malignant disease. Benign silent tumors should be explored and usually resected for one of three reasons: (1) They may continue to grow and subsequently produce pressure symptoms; (2) it is necessary to resect them for histological examination to exclude carcinoma, and (3) certain ones have a propensity to undergo carcinomatous degeneration.

Tuberculomas should be resected and examined not only to differentiate them with certainty from malignant disease but also to eliminate a possible source of dissemination of the disease.

DISCUSSION

DR. FRED R. HARPER, Denver: I was very much interested in Dr. Bisgard's paper, particularly with reference to mass x-ray surveys.

Three years ago we had a mass x-ray survey in Denver, in which 85% of all the people of Denver were x-rayed. Well over 300,000 persons had chest x-rays taken. Our experience was similar to Dr. Bisgard's as to the type of lesions discovered by the survey. There was another important result of the survey in that it recorded the condition of all of these persons' chests as of three years ago. By referring to the x-rays which were taken then, we have discovered things we had not formerly thought possible.

I have in mind one patient who is in the hospital. I saw this patient because of a small round lesion in the upper lobe of the left lung which seemed very insignificant. It was overlooked on the mass x-ray survey, but when the films were reviewed the lesion was seen, and it had not changed in three years. An exploratory thoracotomy was done, and the lesion was found to be adenocarcinoma of the lung, very similar to the one Dr. Bisgard has shown us.

First, such cases illustrate the importance of having a record of patients' chests in the form of x-rays which can be referred to for changes, and secondly, it shows that a carcinoma can be present without appreciable increase over the three-year period.

Dr. Thomas James Kinsella, Minneapolis: The lesions which Dr. Bisgard has shown are, for a number of reasons, very interesting to those of us who are dealing with chest disease. We are now, because of numerous x-ray surveys which are being made, seeing lesions which are totally foreign to our previous experience, leaving us all too frequently unable to make a definite diagnosis. I feel that one may subject a patient to several hundred dollars worth of special examination, but still at the end of the studies know little more than when one started. What one may think is a very accurate diagnosis, taking all information into consideration, may well prove to be completely wrong. From a rather extensive experience over the past several years, we have come to the conclusion that if we are confronted with an isolated lesion within the lung, the only safe and certain way to handle the situation is to excise the nodule surgically, have an immediate pathological examination made, and then proceed with treatment as indicated from the findings obtained.

I have recently resected an isolated nodular lesion from the lung which had remained unchanged as shown by x-ray films for a period of four and a half years, and yet it was an adenocarcinoma without glandular involvement. I recall one patient in whom a tumor had progressed from a small, 1 cm., nodule to a resectable, but not curable, carcinoma in seven and one-half years. We are learning more about bronchogenic carcinoma. Previously, we did not think such things were possible in this disease.

Recently there has been some discussion as to the benign character of calcium-containing nodules. I feel personally that it is unwise and unsafe to trust any of them. Recently on the service of the physician who has advanced the above theory, a patient was allowed to go for several months without surgical intervention for a nodular lesion which was interpreted on the x-ray film as containing calcium. Subsequently the lesion was resected surgically and found to be carcinomatous without any gross calcium present. This was an error of x-ray interpretation and illustrates the danger of making too fine a differential diagnosis in case of lesions of this type.

We must realize that the hazard of delay may be much greater than the risk of surgical exploration, excision, and establishment of a definite pathological diagnosis.

Dr. J. Dewey Bisgard, Omaha: I wonder, Dr. Schmidt, if Dr. Kinsella made the point you wanted emphasized, the necessity of exploring all doubtful lesions.

Dr. Harper's remark about having a record that one can refer to subsequently is a very good one. I didn't say, and I take this opportunity to say, that in the survey studies there have been brought to light quite a number of other lesions, such as cardiac lesions. For example, coarctation of the aorta has been picked up by the finding of notching of the ribs. Also a number of lesions and deformities of the spine and chest not included in my paper have been revealed by the surveys.

TREATMENT OF MITRAL STENOSIS BY FINGER FRACTURE VALVULOTOMY

FRANK GERBODE, M.D.
EMILE HOLMAN, M.D.
AND
HERBERT HULTGREN, M.D.
SAN FRANCISCO

THE DEVELOPMENT of a satisfactory technique for the relief of mitral stenosis has been one of the most challenging problems in surgery. The prediction that surgeons would operate upon the mitral valve was made by Samways in 1898.[1] Shortly thereafter Sir Lauder Brunton investigated the problem of mitral stenosis experimentally and suggested that improvement might follow surgical incision of the diseased valve.[2] This statement led to the publication of a series of letters in *The Lancet* for 1902, most of which were opposed to this type of surgery. During the next 20 years the subject was explored seriously in this country, both in the laboratory and clinically.[3] It is interesting to recall that Harvey Cushing was one

Aided by a grant from the Life Insurance Medical Research Fund.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Nov. 30, 1951.

From the Department of Surgery and the Cardiovascular Laboratory, Stanford University School of Medicine, Stanford University.

1. Samways, D. W.: Cardiac Peristalsis, Its Nature and Effects, Lancet **1**:927, 1898; Correspondence, ibid. **1**:548, 1902.

2. Brunton, L.: Preliminary Note on the Possibility of Treating Mitral Stenosis by Surgical Methods, Lancet **1**:352, 1902.

3. (*a*) Cushing, H., and Branch, J. R. B.: Experimental and Clinical Notes on Chronic Valvular Lesions in the Dog and Their Possible Relation to a Future Surgery of the Cardiac Valves, J. M. Res. **12**:471, 1907-1908. (*b*) von Haecker, R.: Experimentelle Studien zur Pathologie und Chirurgie des Herzens, Arch. klin. Chir. **84**:1035, 1907. (*c*) Bernheim, B. M.: Experimental Surgery of the Mitral Valve, Bull. Johns Hopkins Hosp. **20**:107, 1909. (*d*) Schepelmann, E.: Versuche zur Herzchirurgie, Arch. klin. Chir. **97**:739-751, 1912; Herzklappen Chirurgie: Experimentelle Untersuchungen, Deutsche Ztschr. Chir. **120**:562, 1913. (*e*) Carrel, A., and Tuffier, T.: Étude anatomopathologique et expérimental sur la chirurgie des orifices du coeur, Presse méd. **22**:173, 1914. (*f*) Allen, D. S., and Graham, E. A.: Intracardiac Surgery: A New Method: Preliminary Report, J. A. M. A. **79**:1028, 1922. (*g*) Cutler, E. C., and Levine, S. A.: Cardiotomy and Valvulotomy for Mitral Stenosis: Experimental Observations and Clinical Notes Concerning an Operated Case with Recovery, Boston M. & S. J. **188**:1023, 1923. (*h*) Allen, D. S.: Intracardiac Surgery, Arch. Surg. **8**:317, 1924. (*i*) Cutler, E. C.; Levine, S. A., and Beck, C. S.: The Surgical Treatment of Mitral Stenosis: Experimental and Clinical Studies, ibid. **9**:689, 1924. (*j*) Beck, C. S., and Cutler, E. C.: A Cardiovalvulotome, J. Exper. Med. **40**:375, 1924. (*k*) Cutler, E. C.: The Surgical Aspect of Mitral Stenosis, Arch. Surg. **12**:212, 1926. (*l*) Pribram, B. O.: Die operative Behandlung der Mitralstenose, Arch. klin. Chir. **142**:458, 1926.

of the first to investigate the possibility of producing mitral stenosis experimentally, with a view toward its relief by surgical intervention.[3a]

During this period a good deal of effort was expended on the development of instruments to incise or cut away a portion of the mitral valve and to view the valve while it was being incised. Cutler, Levine, and Beck, and others applied the technique of excision of a portion of the margin of a valve leaflet to a series of patients. The instruments they used were passed through the left ventricle in seven instances, and in two, the left auricular approach was used. Of nine patients, eight died in the postoperative period.[4] One patient survived four and one-half years, although her activities were those of a semi-invalid, and it is difficult to say whether she was improved by the procedure. In the main, these early efforts were so discouraging that operations for mitral stenosis were abandoned in the early 1920's.

Of the various techniques which have been used in the treatment of mitral stenosis, that of finger fracture, as advocated by Harken and others, has the greatest ease of application and is probably the best available method for the surgical treatment of the great majority of these patients.[5] Bailey and his group advocate incision of the commissures in most instances, a method which Harken employs when a satisfactory fracture of the commissure is not possible.[6] It is interesting to recall that the digital approach to the mitral valve through an incision in the left auricular appendage was employed by Souttar in 1925 upon a 15-year-old girl (Fig. 1).[7] Although he had planned to divide the stenotic valve by passing a thin hernia bistoury along his finger, he was content at the time with finger dilation, since he felt that the regurgitation she had would be made worse by incising the anterior leaflet. His patient made a good recovery and lived for five years after the operation with definite improvement but then died of a cerebral embolus. It is difficult to understand why this method of valvulotomy did not gain widespread acceptance at the time.

4. Cutler, E. C., and Levine, S. A.: Cardiotomy and Valvulotomy for Mitral Stenosis: Experimental Observations and Clinical Notes Concerning an Operated Case with Recovery, Boston M. & S. J. **188**:1023, 1923. Cutler, E. C.; Levine, S. A., and Beck, C. S.: The Surgical Treatment of Mitral Stenosis: Experimental and Clinical Studies, Arch. Surg. **9**:689, 1924. Cutler, E. C., and Beck, C. S.: Present Status of Surgical Procedures in Chronic Valvular Disease of the Heart: Final Report of All Surgical Cases, ibid. **18**:403, 1929.

5. (*a*) Harken, D. E.; Ellis, L. B.; Ware, P. F., and Norman, L. R.: Surgical Treatment of Mitral Stenosis, New England J. Med. **239**:801, 1948. (*b*) Harken, D. E.; Ellis, L. B., and Norman, L. R.: The Surgical Treatment of Mitral Stenosis: II. Progress in Developing a Controlled Valvuloplastic Technique, J. Thoracic Surg. **19**:1-15, 1950. (*c*) Sweet, R. H., and others, in discussion on Harken, Ellis, and Norman [5b] and on Bailey, Glover, and O'Neill,[6b] ibid. **19**:45-49, 1950. (*d*) Harken, D. E.; Dexter, L.; Ellis, L. B.; Farrand, R. E., and Dickson, J. F., III: The Surgery of Mitral Stenosis: III. Finger Fracture Valvuloplasty, Ann. Surg. **134**:722, 1951. (*e*) Baker, C.; Brock, R. C., and Campbell, M.: Valvulotomy for Mitral Stenosis: Report of 6 Successful Cases, Brit. M. J. **1**:1283, 1950.

6. (*a*) Bailey, C. P.: The Surgical Treatment of Mitral Stenosis (Mitral Commissurotomy), Dis. Chest **15**:377, 1949. (*b*) Bailey, C. P.; Glover, R. P., and O'Neill, T. J. E.: The Surgery of Mitral Stenosis, J. Thoracic Surg. **19**:16, 1950. (*c*) Glover, R. P.; Bailey, C. P., and O'Neill, T. J. E.: Surgery of Stenotic Valvular Disease of the Heart, J. A. M. A. **144**:1049, 1950.

7. Souttar, H. S.: The Surgical Treatment of Mitral Stenosis, Brit. M. J. **2**:603, 1925.

An indication of the frequency of mitral stenosis among patients who die of chronic valvular disease without active endocarditis has been furnished by the pathologic study of Clawson and his associates.[8] Among 130 such patients with chronic valvular disease, 114 deaths were due to cardiac failure, and 16 to other causes. There were 43 cases in which the mitral lesion was chiefly or entirely stenosis with a normal aortic valve, an incidence of 33%. These patients had a shorter life expectancy than those with aortic stenosis, their average age at death being 41 7/10 years. In contrast, in 29 patients in whom the aortic lesion was chiefly or entirely stenosis, with a normal mitral valve, the average age at death was 55 8/10 years.

A brief consideration of the function of the valve leaflets is in order. The anterior leaflet of the mitral valve acts as a baffle during ventricular systole, directing the

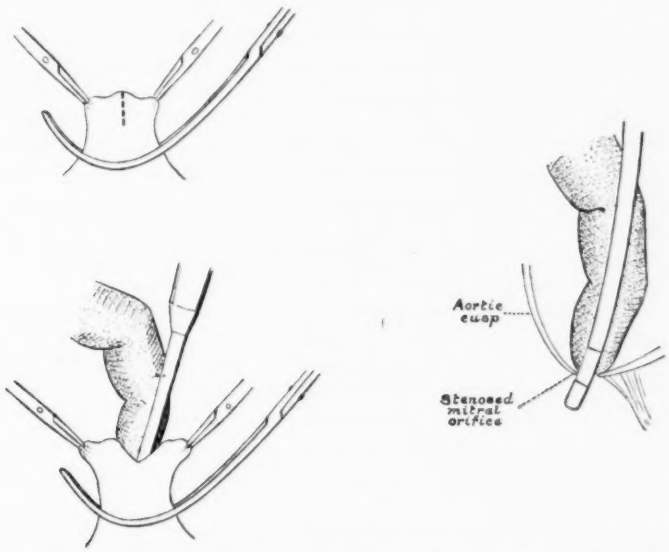


Fig. 1.—Original illustration of the operation for mitral stenosis, as described by Sir Henry Souttar [7] in 1925. Although he had intended to cut the valve with the thin bistoury, as illustrated, he found that enlargement with the finger sufficed. (Reprinted with the permission of Sir Henry Souttar.)

flow of blood into the aorta. Any insufficiency in the anterior leaflet therefore is apt to permit regurgitation of blood into the left atrium with each contraction of the ventricle. The posterior leaflet, however, lies close to the ventricular wall, particularly in ventricular systole, and does not form a baffle for the aortic outflow tract. Defects in the posterior leaflet are tolerated much better than those in the anterior leaflet. The true character of the action of the valves can be appreciated by palpation in the experimental animal; with each systole the valves balloon out and fill the mitral orifice. Most of the tenting occurs in the anterior leaflet, since it bears the full impact of blood being forced over it and into the aorta.

8. Clawson, B. J.; Bell, E. T., and Hartzell, T. B.: Valvular Diseases of the Heart with Special Reference to the Pathogenesis of Old Valvular Defects, Am. J. Path. **2**:193, 1926.

The pathologic physiology of mitral stenosis has been well documented.[9] The inflammatory valvulitis of acute rheumatic fever is followed by scarring and fibrous contraction and produces a severe degree of mechanical block at the mitral valve, converting a normal opening admitting three fingers into a rigid orifice often barely admitting the tip of the index finger. This allows a limited amount of free regurgitation during systole and marked obstruction to auricular emptying during diastole. The volume of blood from the left ventricle into the auricle in systole is usually small because of the easier flow of blood through the normal aortic valve orifice. In diastole, however, from 40 to 60 cm. of blood must move through the orifice from the auricle to the ventricle in about half a second or less. This may not occur with the normal left auricular pressure of 6 mm. of Hg, and, as a result of back pressure, the left auricular pressure may rise to mean values of 20 or 30 mm. of Hg. This pressure is transmitted via the pulmonary veins directly to the capillary bed of the lung and beyond to the pulmonary arterioles and the pulmonary artery. When the pressure in the pulmonary capillaries exceeds a level of approximately 30 mm. of Hg, exudation of fluid into the alveoli and pulmonary edema occur. Stiffening of the lung by capillary engorgement and probably by reflexes from the tense pulmonary veins contributes to the acceleration of respiration and dyspnea. As a consequence of the pressure rise in the pulmonary vascular bed, anatomical changes occur in the capillaries and arterioles, causing a narrowing of these vessels and an increase in the resistance to blood flow, with further elevation of pulmonary artery pressure. Exercise, by increasing the heart rate, further augments the pressure rise in the left auricle and in the pulmonary artery.

Apparently, a considerable decrease in the size of the mitral valve orifice can occur before significant elevations of left auricular pressure are produced. A critical diameter is then reached which if decreased more, even though slightly, will result in marked elevations of auricular pressure. It is in such cases that surgical intervention is most efficient, for then even slight increases in orifice diameter may be accompanied by striking falls in left auricular pressure. In the absence of active rheumatic inflammation of the valve, such alterations of the orifice may be expected to persist and not to disappear as a result of further scarring.

The surgical pathology of mitral stenosis has been classified by Harken along the following lines: Type I represents a rigid zone of fusion between the major and minor leaflets in which there may or may not be calcific deposits. The chordae tendineae and papillary muscles are essentially normal. The majority of patients with mitral stenosis have this type. When the fusion bridges are broken by finger fracture, the valves may resume nearly normal flexibility and minor degrees of regurgitation may be corrected. Type II represents a uniform fusion which forms an elastic funnel into the mitral orifice with an extension of the scarring into the chordae tendineae. This causes them to be shortened and thickened and may even form a secondary stenotic opening. This type of mitral stenosis does not respond well to finger frac-

9. (*a*) Gorlin, R.; Sawyer, C. G.; Haynes, F. W.; Goodale, W. T., and Dexter, L.: The Effects of Exercise on the Circulatory Dynamics in Mitral Stenosis, Am. Heart J. **41**:192, 1951. (*b*) Ellis, L. B.; Bloomfield, R. A.; Graham, G. K.; Greenberg, D. J.; Hultgren, H. N.; Kraus, H.; Maresh, G.; Mebane, J. G.; Pfeiffer, P. H.; Selverstone, L. A., and Taylor, J. A.: Studies in Mitral Stenosis: I. A Correlation of Physiologic and Clinical Findings, A. M. A. Arch. Int. Med. **88**:515, 1951. (*c*) Graham, G. K.; Taylor, J. A.; Ellis, L. B.; Greenberg, D. J., and Robbins, S. L.: Studies in Mitral Stenosis: II. A Correlation of Post-Mortem Findings with the Clinical Course of the Disease in 101 Cases, ibid. **88**:532, 1951.

ture and may require incisional valvuloplasty. It would seem, however, that the results from any type of incision of these valves would not produce nearly the same degree of benefit as in Type I, for the flexibility of the valves is not restored. Generally speaking, if there is calcium present, as there usually is, finger fracture is much more apt to be accomplished easily than if there is a thick fibrous fusion.

The selection of patients for operation can usually be made on the basis of clinical findings, and in rare instances only is cardiac catheterization required to evaluate fully the circulatory disability. The mere presence of mitral stenosis is not considered an indication for operation, since many of these patients have few or no symptoms and under a proper medical regimen can live a normal life span with moderate or no limitation of activity.[10] However, any adult with mitral stenosis who begins to have progressive disability from this disease should be considered for operation. Failure of circulatory compensation is usually manifested by symptoms which are referable to pulmonary vascular engorgement; such symptoms are cough, dyspnea, hemoptysis, and chest pain. The presence of variable degrees of right-sided heart failure, as shown by elevation of peripheral pressure, enlargement of the liver, and edema of the extremities, increases the hazard of operation, but with a suitable period of preparation a considerably improved status may be reached and the operation performed. Ideally, one would prefer to operate upon those patients in the younger age group—between 20 and 40—with moderate to severe symptoms caused by stenosis with little or no regurgitation, but some of our most dramatic results have occurred in patients between the ages of 40 and 55 with high grade stenosis. There are a number of contraindications to operation: uncontrollable cardiac failure, moderate to severe mitral insufficiency, other valvular involvement, enlargement of the left ventricle, active rheumatic disease, and bacterial endocarditis. Auricular fibrillation and slight mitral insufficiency are not contraindications.

Candidates for valvulotomy require special care during the preoperative period. Many of them have been on a rather stringent regimen of salt restriction and limitation of fluids. This, with the administration of mercurial diuretics, we have reason to believe, may lead to difficulties with their physiological management during and immediately after the operation. It is our current practice to liberalize the salt intake for several days before the operation for those patients who have required marked limitation of salt and to give them from 3 to 5 gm. of isotonic sodium chloride intravenously on the day of operation. Digitoxin or digitalis had been administered to most of the patients, and the only special attention given to this aspect of the preoperative care was to attain a slow pulse, with as much control of auricular fibrillation, when present, as was possible. The usual daily dose was given early in the morning of the day of operation. Quinidine sulfate was not used as a preoperative drug.

The anesthesia requirements of these patients vary tremendously, and the services of an expert anesthesiologist is of primary importance. Usually approximately 1/6 grain of morphine sulfate and 1/150 grain of scopolamine hydrobromide were given preoperatively. Anesthesia was induced with thiopental sodium (pentothal® sodium) intravenously, and in some instances intubation was aided by giving a small amount of decamethonium bromide (syncurine®). In all cases an effort was made to maintain the patient under a high oxygen intake, and for this reason ether was favored over nitrous oxide as an inhalation anesthetic agent.

10. Gorlin.[9a] Ellis.[9b]

OPERATIVE TECHNIQUE

In one group of patients we employed a posterolateral incision through the fourth interspace, without division of the ribs but with incision of the intercostal muscles from the transverse process to beyond the costochondral junction. The patient was then turned backward somewhat so that a slightly anterior view of the left side of the heart was obtained. This incision gave the

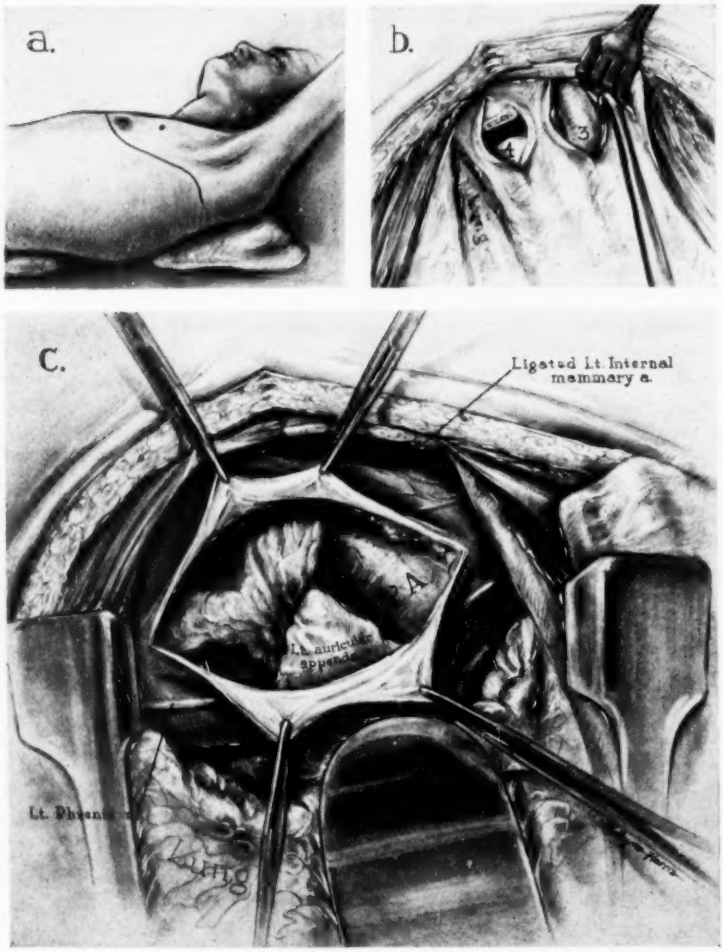


Fig. 2.—Approach to the left auricular appendage. (*a*) Skin incision is made over fourth interspace. It is not carried into the axilla but curved away from it. (*b*) Segments of third and fourth costal cartilages are excised to prevent rubbing postoperatively. Cartilages are not resutured, and in a few weeks a firm fibrous union results. (*c*) Pericardium is usually opened anterior to the left phrenic nerve. It is generally advisable to divide the internal mammary artery.

best view of the posterior and lateral aspects of the auricular appendage. However, in a number of patients hypotension developed, which at times was profound, when they were placed in the lateral position. In one instance the blood pressure fell to a very low level when an anesthetized

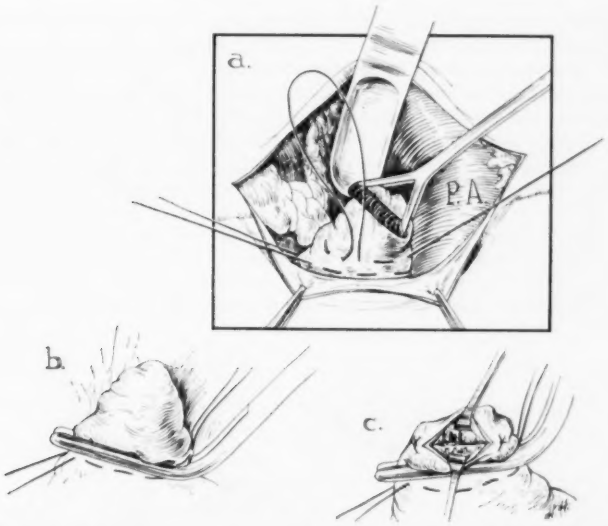


Fig. 3.—(*a*) A rubber-shod lung clamp is useful for traction while the 0 waxed braided sutures are placed. (*b*) The occluding clamp is held by the first assistant and is not closed tightly. Crushing the auricle favors thrombosis. (*c*) The incision into the auricle is made in the segment beyond the clamp, care being taken to sever the chordae tendineae. The two sutures at each end discourage tearing during the intracardiac manipulation.

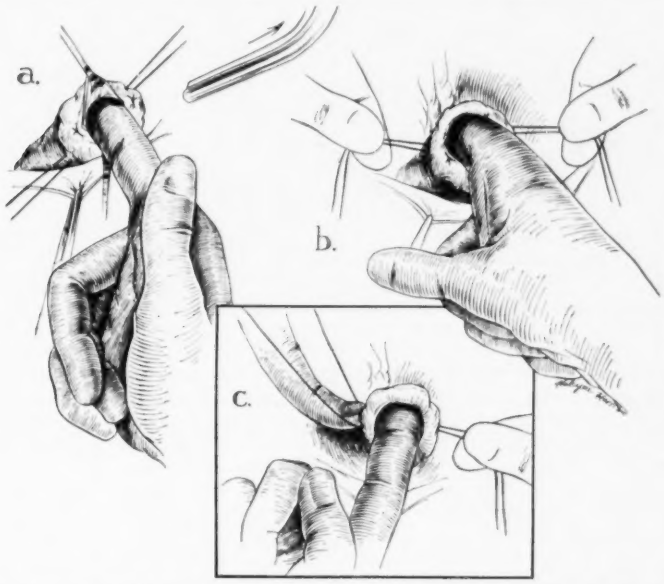


Fig. 4.—(*a*) While the assistant removes the clamp, the finger is inserted into the atrium. The Allis forceps are removed at this point to prevent tearing. (*b*) During the intra-atrial exploration and valvulotomy a little tension is maintained on the purse strings to prevent bleeding. (*c*) The first assistant ties the lowermost purse-string suture while the finger is withdrawn. The second-string suture is then tied. It may be necessary to reapply the clamp.

patient was turned on her right side and rose a little only when she was returned to the supine position. We postponed the operation and subsequently exposed the heart through an anterior incision, with no recurrence of the hypotension and with an excellent result from the procedure.

At the present time we are using an anterolateral incision through the fourth interspace, with the resection of a small segment of the third and fourth costal cartilages (Fig. 2). The patient lies in the supine position but with a pad under the left shoulder and hip. In most instances the pericardium was incised longitudinally about 2 cm. anterior to the phrenic nerve. Kocher clamps were so placed on the pericardium that they could be used for countertraction to avoid displacement of the heart during intracardiac manipulation. Although we used procaine hydrochloride locally and about the base of the auricle in some of the earlier cases, we have now discarded it without noticing any change in the behavior of the heart. Furthermore, although procaine amide was on hand to be injected intravenously, it was given only in a few instances when the heart seemed unusually sensitive to manipulation. A purse-string suture of 0 waxed braided silk on an

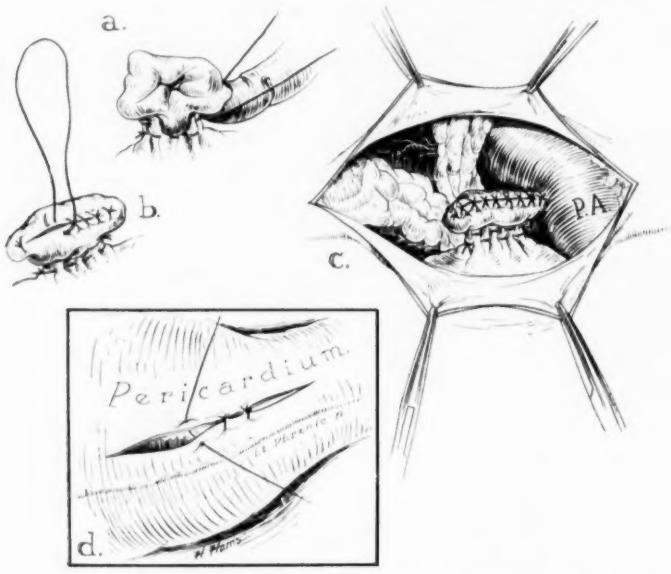


Fig. 5.—(*a*, *b*, and *c*) Details in the final closure of the auricle. Closure of the incision is considered important, since the purse-string sutures may loosen subsequently. (*d*) The pericardium is closed loosely to permit fluid to drain into the thorax.

atraumatic curved needle was placed around the base of the auricular appendage so that the ends could be brought out to the lowermost portion of the auricle, and another purse-string suture of the same type was placed just above the initial one, with the free ends being brought out at the superior margin of the auricular appendage (Fig. 3). An occluding clamp was applied above the purse-string sutures but was not closed tightly. An incision was then made in the auricular appendage above the clamp, care being taken to cut through all the muscle bundles within the auricle. Thrombi were encountered three times in the auricle. On two occasions they had obliterated the end of the appendage, requiring the application of another occluding clamp beneath the first one to get beyond the adherent thrombi. On one occasion a large soft mass, which was densely united to the medial atrial wall, was encountered. It felt like a myxoma but was most likely an old adherent thrombus. Removal was not feasible. A passage to the mitral valve was made by separating it digitally from the lateral atrial wall, and a good result has followed the valvulotomy. To minimize the danger of tearing the ends of the incision during intracardiac manipulation, a single silk suture was passed through just beyond the ends

of the incision. The right index finger was inserted into the atrium as the clamp was removed (Fig. 4). The mitral valve orifice was located, and an estimate of its size and shape was made and any regurgitation noted. Likewise, the mobility of the anterior leaflet was assessed. With pressure being exerted mainly in the direction of the anterior commissure, the finger was forced through the valve opening. In most instances the anterior commissure fractured with this maneuver, although in several patients the posterior commissure separated, and in some both commissures were fractured. Most of the time the valve orifice was entered two to three times during the process of enlarging the opening.

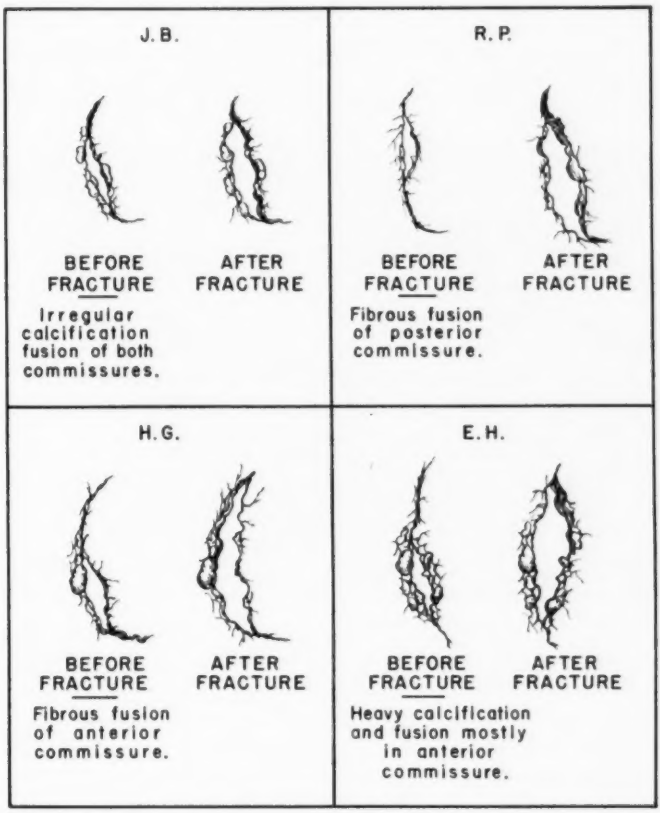


Fig. 6.—Copies of sketches done after operation by the operator, illustrating what was found and accomplished.

Generally, the mitral valve before fracture barely admitted the very tip of the index finger, and after fracture, the valve accommodated the index finger with ease (Figs. 6 and 7). Before withdrawing the finger the degree of regurgitation, if any, was noted. In the early cases the clamp was reapplied to the auricle as the finger was withdrawn, the open auricle was closed with a continuous silk suture, and the purse-string sutures were tied. Recently, we have found it simpler to tie the lower purse-string suture as the finger is withdrawn, then tie the upper suture, and finally close the opening with a continuous silk suture (Fig. 5). The pericardium

was loosely approximated with three or four interrupted silk sutures. The thorax was closed in the routine manner, with intercostal underwater sealed drainage. In most instances about 250 cc. of serosanguinous fluid collected in the first 48 hours, at which time the drainage tube was withdrawn. The patients were placed in oxygen tents for approximately two days, although at times this seemed unnecessary and at other times a longer period was indicated.

The administration of intravenous fluids was carefully controlled both during operation and immediately postoperatively. In most instances 500 cc. of 5% dextrose in water or isotonic sodium chloride solution was given during the beginning of the operation. Blood was started before the valvulotomy was performed so that any loss could be replaced immediately. More than 500 cc. was seldom required; frequently about half the unit was given during the operation and the other half in the postoperative period.

In many of these patients, auricular fibrillation developed in the immediate postoperative period, but it was always controlled by increasing the digitalis effect with digitalis leaf by mouth and digoxin intravenously or by mouth. As a rule, those patients who had sinus rhythm

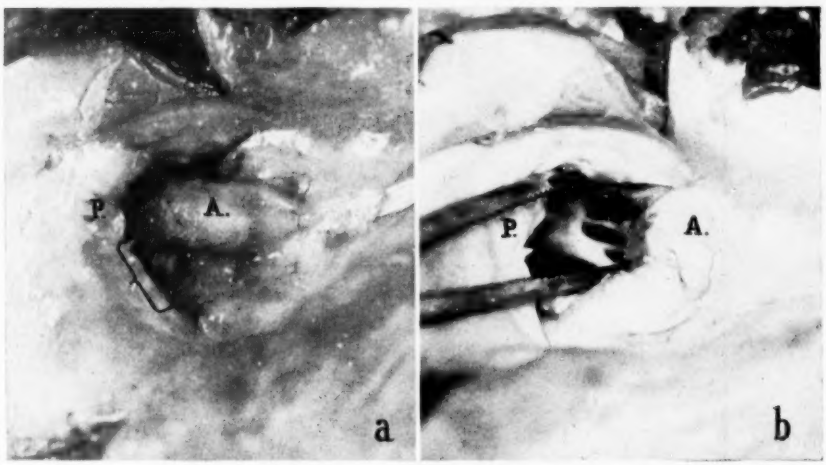


Fig. 7.—Necropsy specimen of the mitral valve in a patient who had an excellent valvulotomy but who died in a state of profound hypotension. (*a*) Before fracture the orifice barely admitted the tip of the index finger, as indicated by the bracket. No regurgitation could be felt after valvulotomy. (The anterior and posterior leaflets are labeled *A* and *P*.)

before operation and who began having auricular fibrillation postoperatively were subsequently converted with the aid of sulfate. It was usually impossible to convert those who had long-standing auricular fibrillation.

OPERATIVE RESULTS

Fourty-four patients with mitral stenosis have been operated upon during the past 15 months, with 5 operative deaths. The causes of death in these five patients were as follows: One patient, a young man, was operated upon after several episodes of heart failure. He had a markedly enlarged heart with a heavily calcified mitral valve. A moderate amount of pleural and pericardial fluid was present at operation. A fairly good valvulotomy was accomplished, but the patient died of heart failure six hours after the operation. Another man with mitral stenosis and moderate insufficiency died suddenly on the sixth postoperative day of an embolus to the coronary artery. In one patient with borderline failure and a markedly enlarged heart,

ventricular fibrillation developed just as the valvulotomy was being done. Although the heart was defibrillated successfully several times with an electric defibrillator and, in spite of the administration of adequate doses of procaine amide as well as the use of rhythmic cardiac compression, we were unable to restore normal heart action. In two women patients with advanced mitral stenosis an identical form of profound hypotension developed during the immediate postoperative period. It was characterized by a peripheral circulatory collapse with good heart action and a slow pulse. It was refractive to all forms of treatment. One of these patients had what might be called an ideal valvulotomy and the other an adequate one; neither had regurgitation nor other valvular disease. For both salt and fluid had been markedly restricted, and they had received injections of mercurial diuretics during the three

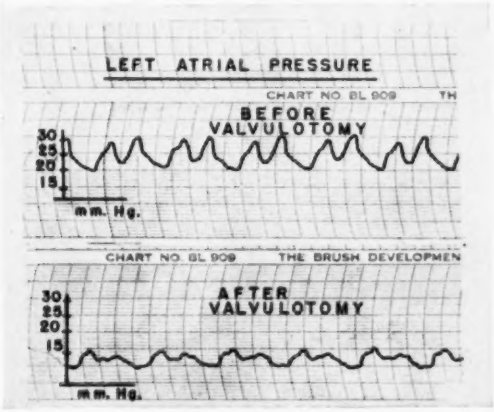


Fig. 8.—Left atrial pressures have been recorded during operation by means of an electromanometer before and after valvulotomy. Generally there has been a reduction in mean pressure of about 10 mm. of mercury.

weeks before operation. Because of the experience with these two patients we now liberalize the salt intake for three days preoperatively by those patients whose salt intake has been severely restricted.

Fourteen of the 44 patients have been observed for four months or longer; the benefit from operation is summarized in the Table. The immediate result in most of the remaining patients has been very satisfactory, but they are not included because of our feeling that a better evaluation of the benefit could be made after they had reached a new base line following the operation. Nine of the 14 patients had marked improvement following the operation, 2 had moderate improvement, and 3 showed slight or no improvement. Several patients who had been completely incapacitated from their disease have returned to full employment without any cardiac symptoms. Most of the women patients were housewives, a number of whom have been able to resume a relatively normal existence after having been confined to bed.

Exercise Capacity and Clinical Symptoms Before and After Mitral Valvulotomy

Patient	Sex	Age	Exercise Capacity		Symptoms		Duration of Follow-Up, Mo.
			Preoperatively	Postoperatively	Preoperatively	Postoperatively	
N. C.	M	33	½ block on level, ½ flight of stairs, no work	Indefinitely on level, 6 flights of stairs, moderate sedentary work	Recurrent hemoptysis; increasing dyspnea and fatigability; 5 yr.	No hemoptysis; no symptoms on moderate activity	15
M. L.	F	31	2 blocks on level, 1 flight of stairs, partial housework	4 blocks on level, 3 flights of stairs, does more work	Attacks of pulmonary edema and hemoptysis, dyspnea, and fatigability for 3 yr.	Less dyspnea and fatigability; occasional less severe attacks of pulmonary edema and hemoptysis	12
T. S.	F	45	¼ block on level, no stairs, bed and chair existence	Indefinitely on level, 3 flights of stairs, does all housework and shopping	Pulmonary edema; increasing dyspnea and fatigability 10 yr.; very severe for 1 yr.	No attacks of pulmonary edema; no symptoms on ordinary activity	11
R. E.	F	26	3 blocks on level, 1 flight of stairs, light housework, unable to work	Slight improvement	Dyspnea on exertion; attacks of pulmonary edema 4 yr.; hemoptysis 4 mo.	Several attacks of pulmonary edema and occasional hemoptysis	9
V. H.	F	28	½ block on level, ½ flight of stairs, cannot work	2 miles on level, 2 flights of stairs, does all housework, to return to work	Dyspnea and fatigue on exertion, with attacks of pulmonary edema for 10 yr., severe 1 yr.	None on ordinary activity	7
M. H.	F	40	5 blocks on level, 1 flight of stairs, partial housework	Indefinitely on level, 4 flights of stairs, does all housework	Attacks of pulmonary edema and hemoptysis fatigability on exertion, 5 yr., severe 1 yr.	No attacks of pulmonary edema; no symptoms on ordinary activity	6
E. C.	F	28	2 blocks on level, ½ flight of stairs, very light housework	Indefinitely on level, 3 flights of stairs, does all housework and shopping	Occasional attacks of pulmonary edema; marked dyspnea	No attacks of pulmonary edema; much less dyspnea	5

R. P.	F	32	1 block on level, very light housework	No improvement	Weakness and dyspnea on exertion; cerebral embolus 14 mo. preoperatively	Less dyspnea	5
J. B.	M	44	Moderate dyspnea on exertion, unable to work	No dyspnea on marked exertion, climbs stairs, works full day	Severe hemoptysis; dyspnea	No hemoptysis; no dyspnea	4
C. E.	F	21	½ block on level, few stairs	Carries 2-year-old child 2 blocks and climbs 2 flights of stairs without dyspnea; returned to work	Hemoptysis; severe dyspnea	No hemoptysis; no dyspnea	4
D. J.	F	41	6 level blocks, 2 or 3 flights of stairs, unable to work	Indefinitely on level, 2 or 3 flights of stairs, returning to work	Frequent nocturnal pulmonary edema, orthopnea, hemoptysis, peripheral edema, 5 yr.	No hemoptysis; no pulmonary edema	4
E. M.	F	38	1 block on level, very light work	Indefinitely on level, 4 flights of stairs, does all housework	Exertional dyspnea 7 yr., paroxysms of nocturnal tachycardia and dyspnea	No dyspnea; sleeps flat	4
D. S.	F	45	1 block on level, no stairs, no work	3 blocks on level, no stairs, light housework	Marked weakness and dyspnea	Some improvement	4
E. Y.	F	48	Indefinitely on level, 1 flight slowly, no work	Indefinitely on level, does nearly all housework	Moderate dyspnea on exertion; paroxysmal nocturnal dyspnea; marked peripheral edema; tender enlarged liver	Less dyspnea; no enlarged liver	4

Twelve patients have been studied physiologically by means of cardiac catheterization before and after operation. Some preliminary observations have been recorded,[11] and further studies on this group are contemplated. The following objective conclusions can be drawn from the data at hand:

1. Two patients exhibited no measurable improvement in function following operation.

2. Ten patients showed moderate to striking degrees of improvement in cardiac function in the following values:

(*a*) Postoperative resting cardiac outputs were 15 to 30% higher, with an increased output on exercise. Two patients who could not increase their output on exercise before operation can do so now by 22 and 29% above the resting level.

(*b*) Arteriovenous oxygen differences at rest and during exercise are lower by 5 to 29%.

(*c*) Pulmonary artery pressures at rest and during exercise are 20 to 40% lower.

(*d*) Resting heart rates and the increase occurring with exercise are less by 10 to 32%.

(*e*) Right ventricular diastolic pressures and peripheral venous pressures approach or reach normal levels, and the increases produced by exercise preoperatively are abolished.

3. Three of the 10 patients had severe pulmonary hypertension with mean pulmonary artery pressures of 70 to 80 mm. of mercury and mild to moderate right ventricular failure. Striking physiological improvement in all these features has occurred in each case. This is an important observation in view of the impression of some workers that severe pulmonary hypertension is a contraindication to mitral valvulotomy.

4. The improvement in function appears to be sustained. In three patients followed up to the present writing for 16, 14, and 13 months respectively, there has been, in fact, a progressive improvement in cardiac function as measured by these physiological means.

SUMMARY AND CONCLUSIONS

The development of mitral valvulotomy, as originally suggested by Souttar, is reviewed briefly.

Patients with mitral stenosis with little or no regurgitation who are experiencing increasing disability from their disease should be considered for operation. The mere diagnosis of mitral stenosis is insufficient reason for operation, since many of these patients do extremely well on a proper medical regimen.

Contraindications to operation are: uncontrollable failure, moderate to severe mitral regurgitation, other valvular involvement, enlargement of the left ventricle, active rheumatic disease, and endocarditis. Auricular fibrillation and slight mitral regurgitation are not contraindications.

Patients whose intake of salt and fluid has been markedly restricted and who have received mercurial diuretics should probably be allowed a liberalized salt intake for several days before operation.

---

11. Hultgren, H. N.; Holman, E.; Gerbode, F., and Stevens, L.: A Physiologic Evaluation of the Surgical Treatment of Mitral Stenosis, Proceedings of the Fundamental Forum on Surgery, American College of Surgeons, to be published.

An anterolateral approach through the fourth interspace with division of the third and fourth costal cartilages is recommended.

The finger fracture type of valvulotomy is recommended because of its relative simplicity and the excellent results which have followed its use in most instances. Fourty-four patients have had valvulotomy performed by this method, with 5 deaths.

Fourteen of these patients have been followed for more than four months after operation. Nine of these have had marked improvement in their physical status, two have had only moderate improvement, and three have shown slight or no improvement.

Twelve patients have had extensive physiologic studies with the aid of cardiac catheterization before and at various intervals after operation. From these data the following objective conclusions can be drawn: 2 patients showed no improvement, 10 patients showed moderate to striking degrees of improvement in cardiac function, as indicated by increases in cardiac output at rest and with exercise and by decreases in pulmonary artery and right ventricular diastolic pressures. Three patients with severe pulmonary hypertension and some right ventricular failure showed striking improvement. The physiological improvement is sustained and is often progressive.

MITRAL STENOSIS

Physiological Studies, Diagnosis, and Treatment

EGBERT H. FELL, M.D.
OGLESBY PAUL, M.D.
CHICAGO

JAMES A. CAMPBELL, M.D.
ALBANY, N. Y.

CARL B. DAVIS Jr., M.D.
LOUIS SELVERSTONE, M.D.
AND
ROBERT GRISSOM, M.D.
CHICAGO

SIR LAUDER Brunton [1] wrote in 1902:

Mitral Stenosis is not only one of the most distressing forms of cardiac disease, but in its severe forms it resists all treatment by medicine. . . . The risk which an operation would entail naturally makes one shrink from it, but in some cases it might be well worthwhile for the patients to balance the risk.

The first question that arises is whether the mitral orifice should be enlarged by elongating the natural opening or whether the valves should be cut through their middle at right angles to the normal opening. I think there can be little doubt that the former would be the better plan, but the latter is the more easily performed (Fig. 1).

The good results that have been obtained by surgical treatment of wounds in the heart emboldens one to hope that before very long similar good results may be obtained in cases of mitral stenosis.

Cutler, Levine, and Beck in 1924,[2] Smithy in 1950,[3] and others have demonstrated that cutting the stenosed (Fig. 2) valves "in the middle at a right angle to

From the Presbyterian Hospital and the Rush Research Laboratories.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo. Nov. 30, 1951.

Dr. Fell is Attending Surgeon at Presbyterian Hospital and Cook County Children's Hospital; Clinical Associate Professor of Surgery, University of Illinois College of Medicine; Consultant in Cardiovascular Surgery, Mount Sinai Hospital.

Dr. Paul is Assistant Attending Physician at Presbyterian Hospital, Central Free Dispensary; Clinical Assistant Professor of Medicine, University of Illinois College of Medicine.

Dr. Campbell is Dean of the Albany Medical School, Albany, N. Y., formerly of Presbyterian Hospital, Chicago.

1. Brunton, T. L.: Mitral Stenosis, Lancet **1**:352 (Feb. 8) 1902; Mitral Stenosis, J. A. M. A. **38**:589 (March 1) 1902.

2. Cutler, E. C.; Levine, S. A., and Beck, C. S.: The Surgical Treatment of Mitral Stenosis: Experimental and Clinical Studies, Arch. Surg. **9**:689 (Nov.) 1924.

3. Smithy, H. G.; Boone, J. A., and Stallworth, J. M.: Surgical Treatment of Constrictive Valvular Disease of the Heart, Surg., Gynec. & Obst. **90**:175 (Feb.) 1950.

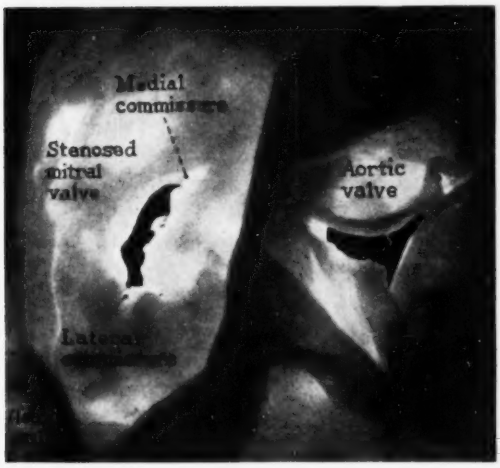


Fig. 1.—Stenosed mitral valve and rather normal-appearing aortic valve are transilluminated. Photograph is taken from left auricular side and shows fish-mouth opening, commissures, heart wall, and septum between aortic and mitral valves. Greatest degree of pathology is usually found a few millimeters about mitral orifice.

Fig. 2.—Photograph of mitral valve taken from the ventricular side, showing thickened papillary muscle and chordae tendineae and difficulties encountered during attempts at valvulotomy from the ventricular approach. This surgical procedure is blind and inaccurate. Results usually are mitral insufficiency and death. Close proximity of aorta and mitral valves is seen.

the normal opening" or removing a portion of the valve at this site causes a mitral regurgitation which is not beneficial to the patient. Souttar [4] and Bailey, Glover, and O'Neill [5] have demonstrated Sir Brunton's prediction that the best plan for surgery would be to "elongate the natural opening." Bailey applies the term "commissurotomy," Harken,[6] the term "valvuloplasty," to mitral surgery. Their objective is the same, to elongate the natural orifice.

In 1924, Cutler, Levine, and Beck [2] reported extensive research and clinical trials for the relief of mitral stenosis. Their review of the literature was extensive, and their results were discouraging to others interested in this problem.

In 1925, Souttar [4] reported a direct attack on the mitral valve by approaching the valve through the left auricular appendage, the stenosed orifice being dilated with the index finger. The operation was of benefit to the patient. Thus, for many years the importance of valvular lesions, experimental and pathological, has been of keen interest to the medical profession, and attempts to relieve patients with these severely crippling diseases were sincere and bold.

Patients who have rheumatic heart disease with mitral stenosis may follow along several different courses in the gradual evolution of their disease. There are some fortunate persons who seem to have a complete subsidence of rheumatic activity in the myocardium and endocardium after one or more episodes of rheumatic fever and are able to lead normal, or essentially normal, lives with an established minimal or moderate mitral stenosis. Such patients do not show signs of a progessive decrease in size of the mitral valve orifice associated with increasing impairment of their cardiac reserve. Their cardiac status reaches an apparent status quo, and such minimal disability as may be present is well tolerated.

A second group of patients is characterized by the presence of truly significant and distressing and often disabling symptoms. These persons usually give a history of increasing dyspnea, which perhaps appears at first only just prior to the menses or when considerable physical effort is exerted, often have coughed up blood, and may have complained of some ankle swelling. Their respiratory symptoms may be so disturbing as to interfere with sleep, and, if considerable right heart failure is present, there may be aching in the right upper abdominal quadrant which occurs particularly on walking and is due to liver engorgement. These patients give the picture of a steady impairment of cardiac efficiency which can be traced to two

4. Souttar, H. S.: The Surgical Treatment of Mitral Stenosis, Brit. M. J. **2**:603 (Oct. 3) 1925.

5. Bailey, C. P.; Glover, R. P.; O'Neill, T. J. E., and Redondo Ramirez, H. P.: Experiences with the Experimental Surgical Relief of Aortic Stenosis: Preliminary Report, J. Thoracic Surg. **20**:516 (Oct.) 1950. Bailey, C. P.; Glover, R. P., and O'Neill, T. J. E.: The Surgery of Mitral Stenosis, J. Thoracic Surg. **19**:1 (Jan.) 1950; Surgery of Stenotic Valvular Disease of the Heart, J. A. M. A. **144**:1049 (Nov. 25) 1950.

6. Harken, D. E.; Dexter, L.; Ellis, L. B.; Farrand, R. E., and Dickson, J. F., III: The Surgery of Mitral Stenosis, Ann. Surg. **134**:722 (Oct.) 1951; The Surgical Treatment of Mitral Stenosis: Progress in Developing Controlled Valvuloplastic Technique, J. Thoracic Surg. **19**:1, (Jan.) 1950; The Surgical Treatment of Mitral Stenosis, New England J. Med. **239**:801 (Nov.) 1948.

pathological processes, a persistent smouldering active myocarditis and, very likely, increasing scarring of the mitral valve with progressive diminution in size of the mitral valve orifice.

There are two other groups of patients worthy of mention, namely, those whose mitral stenosis is important chiefly as the result of the appearance of subacute bacterial endocarditis, and those who are disabled not by the heart disease per se but by the damaging effects of emboli thrown into the pulmonary and peripheral vascular circuits from thrombi in the fibrillating right and left auricles.

Needless to say, these four types of patients are not so clearly separated as this discussion might suggest. Patients in the first group for many years may appear in the second group; and the last two categories represent complications of rheumatic heart disease which, while they may constitute the major hazard, are often superimposed on the picture described for patients in the second group.

We believe in our present state of knowledge that patients in the first group do not require surgery. It seems hardly justifiable to subject these patients to a major operation if they are free of symptoms, or essentially free. We have seen persons 50, 60, and 70 years of age with mitral stenosis carrying along well and leading normal lives. Furthermore, there is no long-term follow-up information available as yet on patients who have undergone mitral valve surgery, and so the ultimate benefit of the procedure in terms of 5- and 10-year results is not established. Finally, in this age of rapidly changing techniques, it is entirely possible that methods employed in 1951, satisfactory though they may be, may in 1953 or 1954 be superseded by further advances and refinements resulting in even greater benefit to the patient. It appears reasonable therefore to leave the asymptomatic patient alone at this time.

Surgery has, of course, nothing to offer to patients with bacterial endocarditis and is, indeed, contraindicated. Patients whose difficulties center around embolic phenomena may be benefited by mitral valve surgery, as will be pointed out subsequently, but it has been our experience that thrombus formation and embolism can be prevented, and these patients may be managed satisfactorily by long-term anticoagulant therapy. It is therefore the patient with mitral stenosis with significant and progressive evidences of impairment of his myocardial reserve whom we are interested in operating upon.

Some of the characteristics of patients in this category have already been alluded to. A history of rheumatic fever or chorea can be elicited for approximately three-fourths of the patients with rheumatic heart disease, dependent partly on the diligence of the examiner and on the nearness of the acute episode. Characteristic complaints include dyspnea, orthopnea, hemoptysis (rarely massive), right upper quadrant aching, and edema, as noted; palpitation related to the presence of auricular fibrillation and fatigue is common. The diagnostic features on examination may be briefly indicated in order of their frequency as follows: (1) an accentuated often snapping first sound on auscultation at the cardiac apex; (2) an apical presystolic crescendo and/or diastolic rumble (the two may be occasionally inaudible with rapid heart rates and with gross decompensation, and the presystolic crescendo may be inaudible in the presence of auricular fibrillation); (3) accentuation of the

second sound in the pulmonic area, often palpable; (4) the presence of auricular fibrillation; (5) cardiac enlargement; (6) an apical presystolic thrill; (7) an early diastolic blowing murmur along the upper left sternal border immediately after the accentuated second pulmonic sound, representing functional pulmonic regurgitation (Graham Steell murmur), and (8) signs of congestive heart failure, including rales in the lungs, hepatomegaly, engorgement of the cervical veins, and the presence of edema.

Certain laboratory studies are also essential in establishing the diagnosis. These include the electrocardiogram which with "pure" mitral stenosis reveals broad notched P waves and evidences of right ventricular hypertrophy; if auricular fibrillation is present (as is common in most of the advanced cases), the P waves are, of course, absent. Chest x-ray with fluoroscopy will characteristically indicate enlargement of the left auricle and right ventricle and often unusual prominence of the hilar vessels. Confirmatory evidence as to the diagnosis may be obtained from cardiac catheterization, which will supply such precise data as the degree of elevation of the pressure in the pulmonary circuit and in the right ventricle and auricle and will also give information as to the cardiac reserve present through the ability of the heart to increase its stroke volume and output under stress. An estimate of the mitral valve area may be derived from these data.

Enough has been said about the general features of the disease. What are our specific indications for surgery? Six conditions should be fulfilled, we believe, if a patient is to be considered a suitable candidate. These are the following: (1) that undoubted mitral stenosis is present; (2) that the mitral stenosis is of the predominant valvular lesion (minor degrees of aortic regurgitation or stenosis and of the tricuspid valve involvement are not necessarily contraindications, and mild mitral regurgitation does not preclude operation); (3) as noted above, that significant symptoms are present; (4) that active rheumatic fever is not present, as indicated by our admittedly inferior methods of detection; (5) that there is no evidence of subacute bacterial endocarditis, and (6) that the patient understands the operation is not a cure, comprehends the risk, and desires surgery. We have not excluded patients on the basis of age, heart size, degree of heart failure, or presence of calcification of the mitral valve, although admittedly the younger patients without advanced failure are most suitable.

The medical preparation of the patient for surgery naturally varies with each case. It is eminently desirable to have a period of several days, or preferably weeks, of observation prior to surgery in order to acquaint oneself best with the particular problems involved. It may take considerable time to achieve the best possible state of cardiac compensation, and during the interval the correct dose of digitalis can be found, the response of the patient to diuretics determined if such drugs are necessary, the absence of fever noted, and the possible need of quinidine sulfate or procaine amide hydrochloride to control cardiac irritability estimated. Aside from the routine blood counts and urinalysis, it is wise to have a preoperative electrocardiogram, complete x-ray studies, blood and throat cultures, and blood levels of prothrombin activity, sodium, potassium, chloride, carbon-dioxide-combining power,

nonprotein nitrogen, and the protein and the albumin-globulin ratio. The venous pressure should be determined if cardiac catheterization is not to be performed, and circulation times are of interest for future reference but are not essential. For most patients a low sodium diet preoperatively is necessary and the use of digitalis in conservative dosage is wise if there has been evidence of congestive heart failure or if auricular fibrillation is present. Cardiac catheterization is useful, as was stated, but need not be routine.

REPORT OF CASES

We have to date operated upon 10 patients ranging in age from 25 to 42 years. Seven of these were women, indicating the sex preponderance long recognized in this condition. A past history of definite rheumatic fever or of chorea or both

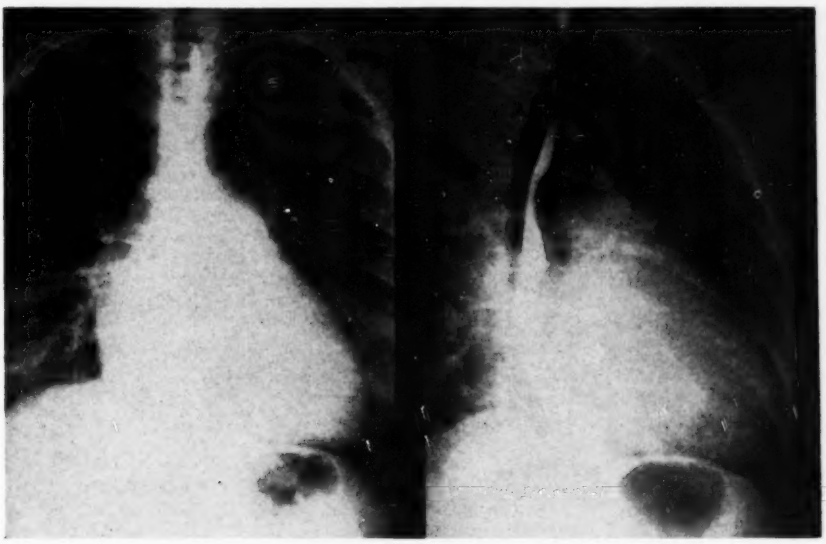


Fig. 3.—Anterior, posterior, and lateral chest x-rays with barium in the esophagus show enlarged heart shadow. Shadows of left auricle, right ventricle, and pulmonary artery are markedly increased. Unusual prominence of hilar vessels is seen. Esophagus is pushed posteriorly by enlarged left auricle. This patient, a 25-year-old woman, was successfully operated upon.

could be elicited in only one-half the cases. Significant symptoms of cardiac disease had existed for five or more years in 9 of the 10 patients, and at the time of operation, none were able to lead a normal life and 2 were total invalids. A review of the symptoms present showed that orthopnea had been present at some time in eight patients, edema in nine, hemoptysis in five, and embolic episodes had occurred in two.

The pertinent physical findings included the characteristic murmur of mitral stenosis in all cases, auricular fibrillation in one-half the series, cervical vein engorgement in three instances, rales in four, hepatomegaly in three, and edema in three. An apical systolic murmur was noted in three patients, with evidence of aortic or

pulmonic regurgitation in a similar number. Cardiac enlargement was present in every case, involving chiefly the left auricle and the right ventricle, as determined by chest fluoroscopy and confirmed by the electrocardiogram (Figs. 2 and 3).

All patients received digitalis preoperatively plus a low sodium diet, and, when indicated, diuretics were employed.

RESULTS

Eight of the 10 patients have survived, and the 7 patients who have now been followed from two to six months postoperatively are all significantly improved, subjectively and objectively. None of these seven patients have experienced a return or orthopnea, and all are able to do more and lead more normal lives than they have for years. Physical examination has shown either the disappearance of

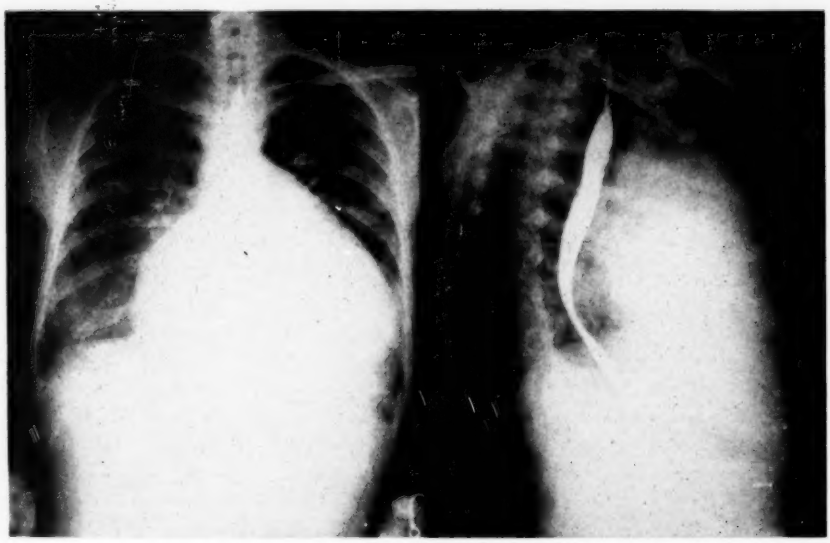


Fig. 4.—X-ray studies of a 36-year-old woman with severe mitral stenosis and no cardiac reserve, with findings more prominent but similar to those described in Figure 2. Patient died of cardiac failure four days after surgery.

evidences of congestive failure or a definite decrease in these signs. The apical diastolic murmur in some instances has disappeared and in others is much less loud. In no patient has there been auscultatory evidence of additional mitral regurgitation resulting from the procedure. No significant alterations in the electrocardiograms have been observed as yet, and the x-ray findings indicate either no change in heart size or a tendency to a decrease. Cardiac catheterization studies have been performed on all patients preoperatively, and on two patients complete postoperative studies have been done at three months. A comparison of these two sets of data (Figs. 4, 5, and 6) shows an increase in the cardiac index at rest and with exercise as the result of the commissurotomy, with a drop in the pulmonary arterial pressure and an increase in the calculated mitral valve area. It will be noted that we have not

restored these mitral valves to normal dimensions but have achieved significant improvement. Microscopic study of the sections of auricular appendage removed at operation have shown evidences of rheumatic activity in five cases.

One patient, 36 years of age, who was in severe cardiac failure at the time of surgery, died on the fourth postoperative day, as noted above, of heart failure combined with the effects of previous pulmonary embolism and of peripheral arterial

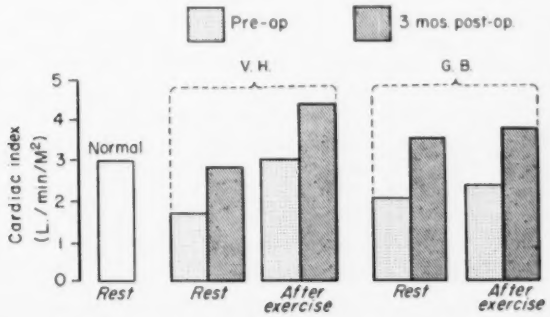


Fig. 5.—Physiological studies on two patients, V. H. and G. B., showing preoperative and three month postoperative mean pulmonary arterial pressure levels at rest and after exercise. The very significant postoperative reduction in pressure in the two patients is clearly illustrated.

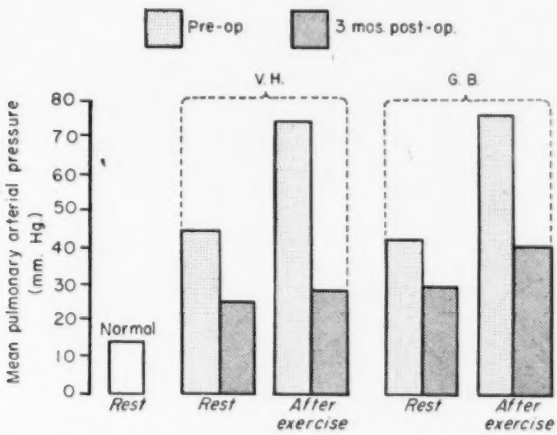


Fig. 6.—Postoperative improvement in cardiac output is illustrated by increase in cardiac index (output in liters of blood per minute per square meter of body surface) in the same two patients, V. H. and G. B., at rest and after exercise.

embolism. The second death occurred 48 hours following surgery on a 38-year-old patient with severe mitral stenosis and auricular fibrillation. Death was due to a cerebral embolism.

SURGICAL PROCEDURE

The chest is entered laterally through the left fourth intercostal space. The technics of Souttar, Bailey, and associates, and Harken [6] are combined and modified for the individual case. The enlarged pulmonary artery and veins, as well as a bulging left auricular appendage, are evident as soon as the lung is retracted.

The pressure in the left auricular appendage is measured by a water manometer, and a sustained high nonfluctuating pressure aids in confirming that the stenosis of the mitral valve is the pathology of importance. The highest pressure we have obtained was 54 cm. of water.

Two heavy silk purse-string sutures are placed about the base of the appendage. Two stay sutures of similar silk are placed at the base of the appendage and have been found most valu-

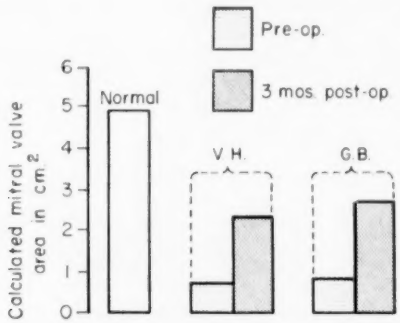


Fig. 7.—Changes in the calculated mitral valve area before and after mitral commissurotomy in patients V. H. and G. B. Despite definite improvement recorded three months after operation, valve orifice remains approximately 50% reduced in size, as compared with normal.

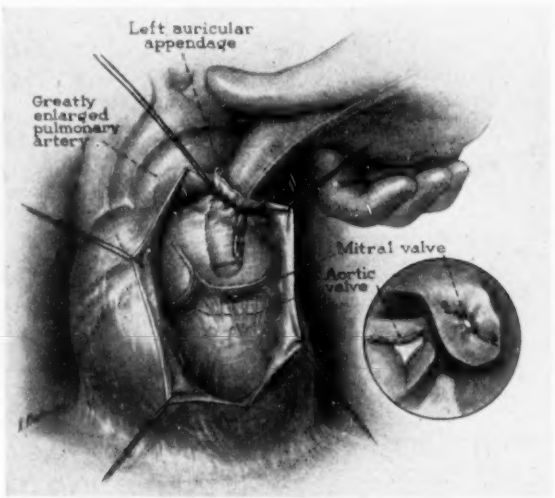


Fig. 8.—Drawing shows the finger with the Baily knife in the left atrium; purse-string suture about the base of the auricular appendage. The finger carefully examines the valve area and pathology; size of the mitral valve orifice and commissures (*a* and *b*) are noted. Commissures can usually be divided with finger pressure. The lateral (*b*) is first opened to the heart wall, the medial (*a*) is then opened partially, care being taken not to injure the aortic septum. The inset is a drawing taken from a transluminated photograph of the mitral and aortic valves, as seen from the atrial and aortic sides of the valves.

able if the purse-string sutures are accidentally cut; traction on the stay sutures allows for application of the auricular clamp. The Satinsky clamp is placed proximal to the purse-string sutures, and after the appendage is amputated, the clamp is released for a fraction of a second

to allow any possible thrombi to be liberated from the auricle. The right index finger with or without the Bailey knife is inserted into the auricle as the clamp is released and the purse-string sutures are drawn about the finger.

The finger examines carefully and gently the auricular cavity (Fig. 8). The valves have varied from a tense tissue-paper-like structure to thick granular calcified barriers. The commissures could be easily identified in all valves. The tip end of the finger could, or barely could, be admitted to the mitral orifice, and in 9 of the 10 cases, division of the commissures could be accurately accomplished by using the finger. The lateral commissure is divided to the cardiac wall, the division starting at the lateral portion of the small fish-mouth orifice; in the case of the tissue-paper-thin stenotic valve, division was accomplished with great ease. On the other hand, it may take considerable effort to divide the commissure with the finger. In the one valve which the finger could not divide, the guillotine knife was of little value; however, after the knife was used, the opening was increased by finger pressure.

After the lateral commissurotomy is completed, the medial commissure is divided gently. To date, in our series of cases, two and one-half or three fingers could easily be introduced into the orifice after commissurotomy, except in one case in which the thick calcified valve defied finger and knife; it was enlarged two and one-half times the size of its original stenosis, or the diameter of the operating finger.

As the finger is withdrawn, the purse-string sutures are closed, and the raw edge of the appendage is oversewn with silk.

The immediate results are dramatic, the enlarged tense left auricle is smaller and less tense and this is confirmed by water manometer readings; likewise, the large pulmonary artery and veins are much less tense. Closed drainage of the chest cavity has been used in all of the cardiovascular cases with benefit, particularly in this series.

The importance of properly administered anesthesia cannot be overemphasized. We are fortunate in having anesthesiologists who study the cases preoperatively and are active in the postoperative care of the patient, as well as administering the proper anesthetic, maintaining an open airway, and watching the oximeter and electrocardiogram for signs of trouble. Needless to say, it takes the anesthesiologist and one or two assistants to do this work well.

We believe that local infiltration of 1% procaine hydrochloride in the intercostal spaces prior to spreading the ribs is beneficial. A local anesthetic in oil injected about the intercostal nerves prior to closure of the wound lessens the acute discomfort for the first 24 to 48 hours.

Some investigators believe amputation of the auricular appendage may decrease the incidence of peripheral emboli. The auricular specimen is studied grossly and microscopically. Four of the patients operated upon have had mural thrombi, and in five microscopic evidence of rheumatic endocarditis and myocarditis was present in spite of the fact that no clinical or laboratory evidence was present prior to surgery nor had there been an acute attack of rheumatic fever for a number of years prior to surgery.

SUMMARY

The indications and contraindications for surgical treatment of mitral stenosis are given.

Clinical, cardiovascular physiological, laboratory, and pathological findings are briefly given concerning patients studied before, during, and after surgery.

Our results confirm those of Bailey, Glover, and O'Neill, Harken, and others. We are convinced that the surgery outlined for the patient suffering from mitral stenosis is at present sound and offers the patient relief and an opportunity to live a more normal life.

ADDENDUM

Since this article was written, 18 additional patients have been operated upon with similar gratifying results.

DISCUSSION

DR. FRANK GERBODE, San Francisco: About half of our patients have had auricular fibrillation either while in the hospital or at some time previous to entering the hospital for operation. A number have required quinidine sulfate for conversion. During the immediate postoperative period, in about half the patients, auricular fibrillation developed, occurring dramatically sometimes in the middle of the night. This condition may require the rapid use of quinidine and digitoxin. We have favored digitoxin, using quinidine only when digitoxin has not controlled the fibrillation.

DR. EGBERT H. FELL, Chicago: Time did not permit the proper emphasis to be made concerning preoperative and postoperative care. It may take a number of weeks to prepare a patient for surgery. Any decompensation should be overcome by digitalization, administration of diuretics, and a low sodium diet. Digitalis and a low sodium diet are maintained after surgery and withdrawn as the patient improves, usually within two to three months. We have not seen an auricular fibrillation revert to a normal rhythm. We make certain that the patient and the family realize that the heart will not be normal after surgery but that the object of the operation is to improve cardiac function so that the patient will be a more comfortable and a more useful person.

RELIEF OF PAIN BY NEUROSURGICAL PROCEDURES

ALFRED W. ADSON, M.D.†
AND
HENDRIK J. SVIEN, M.D.
ROCHESTER, MINN.

NEUROSURGICAL procedures offer relief from intractable pain in many instances when medical and general surgical procedures fail. However, they should not be employed until all medical and physical means have been exhausted. Physical therapy and administration of an analgesic drug usually suffice to relieve pain due to inflammatory lesions such as neuritis, fibrositis, myositis, and arthritis. There is always a temptation to administer a narcotic for pain, but it should be remembered that the administration of a narcotic for more than a few days can readily lead to addiction. Administration of a narcotic is not justified for chronic conditions, with one exception, and that is for an inoperable malignant lesion when the patient's life expectancy is only a few months.

Pain, an unpleasant, disagreeable, often debilitating sensation, results from irritation or stimulation of a sensory nerve or tract which in turn conducts the stimulus to the brain. Interpretation of such stimuli varies from person to person and the interpretation of their severity is exaggerated or minimized by emotions and environment. This variation is referred to as the threshold of pain and this threshold may be high or low in different persons with comparable lesions; that is, one patient may complain of pain from an irritating stimulus of the sensory nerves while another may ignore or minimize the discomfort from a similar stimulus.

Chemical injections of sensory nerves, rhizotomy, chordotomy, and tractotomy are accepted neurosurgical procedures for the interruption of sensory nerves and tracts which conduct painful sensations.

TECHNIC OF TREATMENT

Local infiltration of a sensory nerve with an anesthetic agent, such as piperocaine hydrochloride (metycaine®) will relieve pain for an hour or two. It has no lasting effect unless the psychic effect of an injection may be of some value when there is an associated neurosis. The anesthetic effect often is of diagnostic value in determining whether or not a chemical agent or operation employed to interrupt the function of the nerve is indicated or will be of value in relieving the painful sensation.

Alcohol Injection of Sensory Nerves.—Absolute alcohol or alcohol in concentrations of 95 to 98% is the most effective agent used to destroy a sensory nerve. It

† Dr. Adson died Nov. 12, 1951.

From the Section of Neurologic Surgery, Mayo Clinic.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Nov. 30, 1951.

is wise to anesthetize the patient with nitrous oxide or thiopental (pentothal®) sodium during the injection of 2 to 5 cc. of alcohol, since the immediate effect of the injection is very painful. The destructive effect of the alcohol is decreased if the field is prepared by a local anesthetic, since it dilutes the alcoholic solution.

The injection of the second and third branches of the fifth cranial nerve with alcohol gives excellent temporary relief from trigeminal neuralgia. It is unwise to attempt injection of the first or ophthalmic branch as it enters the orbit, because the alcohol may infiltrate the oculomotor nerves, which lie in the same vicinity, and produce oculomotor paralysis. Injection of the ophthalmic nerve with alcohol at the supraorbital foramen may give slight relief; however, avulsion of this nerve will usually give a longer period of temporary relief.

The technic employed at the Mayo Clinic for alcohol injections of the second or third branches of the trigeminal nerve is as follows: A needle of the trocar cannula type, 8 cm. in length and 1.5 mm. in diameter, is employed. The cannula is graduated in centimeters in order to indicate the depth. The patient is anesthetized with nitrous oxide until he reaches the analgesic state. Then the needle can be inserted without pain. Anesthesia is not allowed to become so deep that the patient is unaware of pain when the needle touches the nerve. Once the surgeon is confident that the needle is close to the proper nerve, nitrous oxide anesthesia in increased until the patient is completely anesthetized before the alcohol is injected.

Injection is made into the mandibular branch of the fifth cranial nerve at its exit from the foramen ovale. The needle reaches this site by piercing the skin at a point 2.5 cm. in front of the descending root of the zygoma, which almost coincides with the anterior bony border of the external auditory meatus. The needle is directed slightly upward along the base of the skull and a little backward at a depth of 4 cm. For injection into the superior maxillary division, the skin is pierced, 0.5 cm. posterior to the external angle of the orbit, underneath the zygoma, and the needle is directed vertically to the anteroposterior line but inclined slightly upward in a direction which should reach the nerve, at a depth of 5 cm., as it emerges from the foramen rotundum.

Paravertebral Injections.—The important landmarks in paravertebral injections are the spaces between the tips of the spinous processes.[1] The anesthetist finds the selected space with the tip of a finger. When the injection is to be made in the lumbar region, the wheal (the superficial injection of the skin) is raised directly opposite the finger tip and about 4 cm. or 2 fingerbreadths from the median line. For an injection in the thoracic region the wheal is raised opposite the upper border of the finger tip; this corresponds to the lower border of the spine of the vertebra above the finger.

A needle 80 mm. in length is then passed in a plane perpendicular to the skin until the point of the needle comes to rest near the end of the transverse process of a vertebra. Following this the needle is partially withdrawn and directed upward and over the upper border of the transverse process. The needle is not passed beyond the space between the transverse processes. The solution is then injected. Since an injection of 2 to 5 cc. of 1% solution of procaine hydrochloride or piperocaine hydrochloride will saturate the spinal nerve as it emerges from the intervertebral foramen, at no time should the needle be directed toward the body of the

1. Lundy, J. S.: Clinical Anesthesia: A Manual of Clinical Anesthesiology, Philadelphia, W. B. Saunders Company, 1942.

vertebra lest the solution may be injected into the spinal canal. This fact is especially important if an injection of alcohol is being made.

Cervicothoracic Sympathetic Block.—The space between the spines of the seventh cervical and the first thoracic vertebra is indentified by the anesthetist with the tip of the index finger.[1] A wheal is raised 2½ fingerbreadths lateral to the midline and opposite this space. An 80 mm. needle is inserted between the transverse processes until the point strikes the lateral surface of the body of the first thoracic vertebra. The point of the needle is advanced along the surface of the body of the vertebra until it lies almost even with its anterior surface. At this point, or just before the needle reaches this point, paresthesia may be obtained similar to the pain incidental to puncture of the wall of a vein. When such paresthesia is obtained, the needle should be immobilized immediately and 15 cc. of 1% solution of procaine or piperocaine hydrochloride should be injected. If the pain is the result of the needle actually striking the sympathetic trunk, the injection will be effective immediately. The effectiveness is usually evidenced by Horner's syndrome developing almost as soon as the patient is turned on his back. When direct contact with the nerve is not made by the needle, Horner's syndrome may not develop for 10 to 15 minutes.

Posterior Splanchnic Block.—The patient is placed in a prone position. A pillow is placed under the abdomen and the anterior-superior iliac spines in such a way as to elevate the vertebral spines and render them easily distinguishable. The prone position is desirable in order to insert the splanchnic needles, one on each side, before injection.[1] Wheals are raised on each side 7 or 8 cm. from the midline near the lower edges of the 12th ribs. A needle 80 mm. long is thrust through each wheal and from 2 to 4 cc. of 0.5% solution of a local anesthetic agent (procaine or piperocaine hydrochloride) is injected along the course to be pursued by the longer needles (120 mm.). These longer needles are placed next, first on one side and then on the other, so that their points rest against the lateral surfaces of the body of the first lumbar vertebra.

If contact of the needle with bone is painful, 2 or 3 cc. of the local anesthetic solution is injected to facilitate moving the point of the needle to the region just anterior to the lateral surface of the body of the first lumbar vertebra. If blood appears, the position of the needle is changed to avoid blood vessels. Frequent aspirations usually will disclose whether the point of the needle has entered a blood vessel. After the point of the needle has made contact with bone (first position) the needle is rotated until the bevel lies against bone and then the needle is slid downward to the second position (step descent). The needle is again rotated until the bevel is down, and search for bone is made. If contact with bone is effected, the needle is again rotated (third position) and is advanced with the bevel against bone. Again the rotary motion is carried out; the bone is palpated with the bevel down (second position), and, if bone is no longer felt, the needle is advanced a short distance so that the point is about on a level with the medial portion of the body of the vertebra (fourth position).

When possible, the splanchnic needle is passed above the transverse process of the first lumbar vertebra, but if necessary on account of pain may be inserted below it. The spinal nerves should be avoided; any paresthesia should be slight and should serve as a warning. If patients are very large, the 120 mm. needle may be thrust in for almost its entire length. For smaller patients, usually two-thirds of the shaft of the needle disappears into the tissue before the prevertebral space is reached.

Lundy [1] has advocated taking roentgenograms of the needles in position before injections are made to assure the accuracy of the injection.

After the needles are in position, 10 cc. of 0.5% solution of procaine or piperocaine hydrochloride is injected slowly, first on one side and then on the other, until from 25 to 50 cc. has been placed on each side. The amount of solution to be used and the rate of injection depend on the patient's ability to tolerate the solution. If signs of intoxication appear, injection may be delayed or discontinued.

As a rule the injection of the sympathetic ganglia and trunks is not too painful; thus, the local infiltration of the skin is sufficient and general anesthesia can be avoided.

Subarachnoid Injection.—Since absolute alcohol is lighter than cerebrospinal fluid, the hydrodynamic problem is to inject a few minims of alcohol into the subarachnoid space in such a manner that it will rise to the surface of the cerebrospinal fluid and come in contact with two or possibly three dorsal roots before diffusion and dilution have taken place.[2] To accomplish this the patient is placed on his side with the spinal roots to be treated situated on the upper side. Further, to assure that the portion of the spinal canal which contains the two roots to be treated with alcohol is higher than any other portion of the canal, a firm pillow is placed under the patient opposite these dorsal roots. The field is prepared as for spinal puncture. A Becton or Dickinson 1 cc. syringe is used in order that too large a dose of alcohol may not be administered. The usual 18-gauge Barker-Luer spinal puncture needle suffices, but it is advantageous to use a smaller needle, one of 21 gauge. Absolute alcohol is preferable to 95% alcohol. In all instances it should be sterilized in an autoclave. The alcohol can be secured in 1 cc. glass ampules.

The needle is introduced through a vertebral space just below or just above the roots to be treated. After the needle has been introduced, 5 drops of cerebrospinal fluid is withdrawn before the alcohol is injected, in order that the alcohol may float across a "water" level and come in contact with the dorsal roots. The procedure is not painful when small quantities of alcohol are used. If the injection has been performed properly, the patient will observe a sensation of warmth over the body, corresponding to the distribution of the nerves that arise from the affected roots. In two or three minutes the painful sensations disappear and are followed by loss of pain and frequently by impairment in temperature and tactile sense. We prefer to give 6 to 8 minims (0.3 to 0.5 cc.) and to reinect, if necessary, rather than to chance injecting too large a dose and thus producing a motor disturbance. The patient is left in the position that has been described, for 15 minutes following the injection, in order that the alcohol may slowly diffuse into the cerebrospinal fluid without becoming concentrated about other structures within the spinal canal. If more than one pair of nerve roots is to be treated, injection should be performed on subsequent days.

Rhizotomy.—Rhizotomy may be applied to the fifth and ninth cranial nerves and to all spinal nerves.[3] For section of the fifth cranial nerve, either a transtemporal or

2. (*a*) Adson, A. W.: The Value of, and Indications for, Intraspinal Injections of Alcohol in the Relief of Pain, Minnesota Med. **20**:135-140 (March) 1937. (*b*) Craig, W. McK., and Adson, A. W.: Relief of Intractable Pains by Nerve Blocks, Root Sections, Chordotomy and Subarachnoid Alcohol Injections, Proc. Interst. Postgrad. M. A. North America, pp. 402-414, Oct. 18, 1937.

3. Frazier, C. H.: Subtotal Resection of Sensory Root for Relief of Major Trigeminal Neuralgia, Arch. Neurol. & Psychiat. **13**:378-384 (March) 1925.

a suboccipital approach may be used. We prefer the transtemporal approach. It consists of temporal craniectomy, decompression, elevation of the dura, control of middle meningeal bleeding, identification of retrogasserian fibers, preservation of the motor nerve, and partial or total section of the sensory root.

For section of the ninth cranial nerve, the glossopharyngeal, a suboccipital unilateral craniectomy is employed. The dura is opened; the cerebellar lobe is elevated, and the three nerves leaving the cranium through the jugular foramen are identified. The cephalad nerve, which is separated from the vagus by a dural band, is the glossopharyngeal nerve. This is then divided by a small right-angle knife.

Rhizotomy of sensory spinal nerves is performed after identification of the roots which lie dorsal to the dentate ligament. Caution should be employed not to injure the blood supply to the cord which follows the spinal roots. Hemostasis of arterioles in the sensory root is accomplished by electrocoagulation with a low current before the sensory fibers are divided. Unilateral hemilaminectomy suffices for exposure if the symptoms of pain are located on one side of the body.

Sympathectomy.—The technic of sympathectomy depends on the rami that are to be divided.[4] If relief of causalgia in the hand is desired, division of the gray rami to the brachial plexus is indicated. This means thoracic resection of the sympathetic trunk, including the second and third thoracic ganglia. In order to improve the circulation and relieve painful lesions of the toes, feet, and legs, the lumbar sympathetic chain, including the second and third lumbar ganglia, must be removed. To perform splanchnicectomy for relief of visceral pains, an incision is made in the loin, and the splanchnic nerves are exposed by means of a subdiaphragmatic extraperitoneal approach.[5] Ray and Console [6] have recommended that a thoracolumbar sympathectomy with section of the splanchnic nerve be done, inasmuch as splanchnic nerve resection alone is not sufficient. A presacral sympathectomy with resection of the superior hypogastric plexus of Havelock is performed through a low midline incision.

Chordotomy.—Chordotomy, or section of the anterolateral tract in the spinal cord, was advocated by Spiller and performed by Martin [7] in 1912. Section of this tract is performed on the opposite side of the cord to that on which the pain is perceived. This procedure results in a loss of pain and temperature perception, with preservation of all other functions. Chordotomy may be performed unilaterally or bilaterally at one of two levels. To interrupt sensation from the feet, legs, and abdomen, chordotomy is performed between the first and second thoracic segments of the cord. In order to relieve pain in areas supplied by the brachial plexus, chordotomy is performed at the first cervical segment on the side opposite to the pain. The operative technic consists of laminectomy, opening the dura, cutting the

4. Adson, A. W.: The Surgical Indications for Sympathetic Ganglionectomy and Trunk Resection in the Treatment of Diseases Resulting from Vasomotor Spasm of Peripheral Arteries, Bull. New York Acad. Med. **6**:17-32 (Jan.) 1930.

5. White, J. C., and Smithwick, R. H.: The Autonomic Nervous System, Ed. 2, New York, The Macmillan Company, 1941.

6. Ray, B. S., and Console, A. D.: Relief of Pain in Chronic (Calcareous) Pancreatitis by Sympathectomy, Surg., Gynec. & Obst. **89**:1-8 (July) 1949.

7. Spiller, W. G., and Martin, E.: The Treatment of Persistent Pain of Organic Origin in the Lower Part of the Body by Division of the Anterolateral Column of the Spinal Cord, J. A. M. A. **58**:1489-1490 (May 18) 1912.

attachment of the dentate ligament and using it as a guide, after rotating the cord, to pass a knife into the cord in a position parallel with and below the dentate ligament for a distance of 3 mm. The knife then is brought downward and to the side to divide the anterolateral tract. White [8] took exception to such a limited chordotomy and gave clinical evidence that axons subserving pain are scattered widely over the anterolateral quadrant of the spinal cord and that it is necessary to divide virtually the whole anterolateral quadrant to secure a high level of analgesia. He preferred to employ as anesthesia for this operation procaine infiltration supplemented by light thiopental sodium and nitrous oxide anesthesia.

After the incision in the cord has been made, the patient is allowed to wake and the level of analgesia is checked. White has stated that often successively deeper incisions are needed to secure satisfactory analgesia. Unilateral chordotomy rarely produces unpleasant sequelae. Extensive bilateral chordotomy may give rise to urinary retention and difficulty of defecation.

Tractotomy of the Spinothalamic Tract.—This is performed in the medulla oblongata [9] or mesencephalic areas.[10] Tractotomy in the medulla is performed after a high cervical laminectomy. It was designed and performed by Schwartz and O'Leary [11] to relieve neuralgia of the shoulder and neck. Sjöqvist [9] developed a tractotomy of the medulla to relieve trigeminal neuralgia. There is no doubt but that occasions arise when tractotomy is indicated, but it should be employed only when every other measure has failed to give relief.

Walker [10a] developed a mesencephalic tractotomy for which a craniotomy approach is employed. The operation interrupts the pain tracts from the entire opposite half of the body by a section of the lateral lemniscus at the level of the mesencephalon. Walker [10a] stated that since the incision is well removed from the motor tracts, no motor or urinary disturbance develops, that postoperative burning paresthesia complicates the results of the operation in 10% of cases, that the mortality rate is 7%, and that mesencephalic tractotomy cannot be performed bilaterally without producing complete deafness.

Prefrontal Lobotomy.—Prefrontal lobotomy or leukotomy appears to be of value in a limited group of patients.[12] The operative procedures are designed to interrupt frontothalamic fibers with a leukotome through trephine openings placed lateral to the longitudinal sinus and just anterior to the coronal suture. The patient selected for this surgical procedure is one who has a pain fixation as a psychoneurosis, who is elderly, and is a chronic invalid. This precaution regarding selection of patients for prefrontal lobotomy is due to the fact that a number of patients, following lobot-

8. White, J. C.: Neurosurgical Treatment of Persistent Pain, Lancet **2**:161-164 (July 29) 1950.

9. Sjöqvist, O.: Eine neue Operationsmethode bei Trigeminusneuralgie: Durchschneidung des Tractus spinalis trigemini, Zentralbl. Neurochir. **2**:274-281 (Jan.) 1937.

10. (*a*) Walker, A. E.: Relief of Pain by Mesencephalic Tractotomy, Arch. Neurol. & Psychiat. **48**:865-880 (Dec.) 1942. (*b*) Walker, A. E.: The Neurosurgical Treatment of Intractable Pain, Journal-Lancet **70**:279-282 (Aug.) 1950.

11. Schwartz, H. G., and O'Leary, J. L.: Section of the Spinothalamic Tract in the Medulla with Observations on the Pathway for Pain, Surgery **9**:183-193 (Feb.) 1941.

12. Koskoff, Y. D.; Dennis, W.; Lazovik, D., and Wheeler, E. T.: The Psychological Effects of Frontal Lobotomy Performed for the Alleviation of Pain, A. Research Nerv. & Ment. Dis., Proc. (1947) **27**:723-753, 1948. White.[8]

omy, become apathetic and confused mentally and thus are prevented from assuming responsibilities. Scarff [13] has reported that unilateral prefrontal lobotomy, which obviates or minimizes effects on the personality and intellect, affords satisfactory relief of pain in 66% of patients.

PAINFUL CONDITIONS RELIEVED BY NEUROSURGICAL PROCEDURES

Trigeminal Neuralgia.—This is a painful neuralgia of the fifth cranial nerve that may involve one or all three branches of the nerve. Temporary relief for one to two years is obtained by an alcohol injection of the second and third branches of the nerve as they leave the skull.[14] Shorter periods of relief of pain are obtained by avulsing the first or ophthalmic branch. Unfortunately, the avulsion cannot be repeated when the pain returns. Alcohol injections of the second and third branches can be repeated. The relief of pain following second and third injections is of less duration than that following the first injection. Therefore, we advise rhizotomy of the sensory root of the gasserian ganglion when pain returns after the first injection. If the pain is limited to the third branch or has been limited to the third and second branches for several years, subtotal section instead of complete section of the sensory root of the gasserian ganglion is the operation of choice. The advantage of preserving the fibers of the sensory root to the ophthalmic branch is that sensation of the cornea is preserved. Its preservation minimizes the possibility of traumatic keratitis from the entrance into the eye of foreign bodies which the patient does not recognize.

Sjöqvist [9] has devised tractotomy in the medulla oblongata for the disease. Technically, his operation is more difficult than rhizotomy of the sensory root of the gasserian ganglion, since, if the incision is placed too low, not all the pain fibers are cut, and if placed too high, ataxia will result.

Glossopharyngeal Neuralgia.—This neuralgia involves the ninth cranial nerve. The paroxysms of pain are extremely severe and resemble those of trigeminal neuralgia except that the pain follows the distribution of the ninth cranial nerve instead of the fifth cranial nerve. The patient is permanently relieved of pain by intracranial section of the nerve. Alcohol injections of the peripheral branches of the ninth cranial nerve are not employed because of the close proximity of the vagus and glossopharyngeal nerves as they leave the skull.

Sluder's Neuralgia.—This is supposed to be a neuralgia of the sphenopalatine nerve. It is considered by some to be a neuralgia of the vidian nerve. Treatment and results are unsatisfactory. Rhizotomy of the sensory root of the fifth cranial nerve does not give relief. Applications of cotton pledgets dipped in a solution of silver nitrate to the mucosa of the nose under the middle turbinate occasionally give relief for what Sluder called a "lower half head pain."

13. Scarff, J. E.: Unilateral Prefrontal Lobotomy for the Relief of Intractable Pain: Report of 58 Cases With Special Consideration of Failures, J. Neurosurg. **7**:330-336 (July) 1950.

14. Grant, F. C.: Surgical Methods for Relief of Pain in the Head and Neck, A. Research Nerv. & Ment. Dis., Proc. (1942) **23**:409-415, 1943. Patrick, H. T.: The Treatment of Trifacial Neuralgia by Means of Deep Injections of Alcohol: Report of 16 Cases, J. A. M. A. **49**:1567-1573 (Nov. 9) 1907. Frazier.[3] Schwartz and O'Leary.[11]

Occipital Neuralgia.—This involves chiefly the second cervical nerve on either side. At times, however, the first and third cervical nerves are involved with the second. When the neuralgia is confined to one nerve, the second cervical, a paravertebral injection of alcohol may suffice to give temporary relief. More often than not, intraspinal rhizotomy of the sensory components of all three nerves (first, second, and third cervical nerves) is required for complete relief of occipital neuralgia.

Intercostal Neuralgia.—One or more of the thoracic nerves may be involved. The same type of pain (sharp, lancinating pain extending along the course of the nerve with hyperesthesia of the skin) may affect any of the spinal nerves. However, the treatment of pain must differ from that employed on sensory nerves when the involved nerve is a mixed nerve which contains important motor fibers such as are found in the brachial and in the lumbosacral plexuses. Intercostal neuralgia may accompany or follow herpes zoster or may develop independently of skin eruptions. It usually involves two or three dermatomes. Not infrequently the disease progresses to involve additional sensory ganglia of spinal nerves at higher or lower levels and nerves of the opposite side. When the disease remains localized, subarachnoid injection of alcohol usually affords relief. Paravertebral injection of the involved nerves with alcohol rarely gives relief because the injection fails to destroy the dorsal ganglion of the nerve. A limited unilateral laminectomy with rhizotomy of the sensory roots frequently has to be resorted to. Even rhizotomy may not give too satisfactory results if the disease is progressive and if the patient has become a narcotic addict.

Lesions of the Brain and Cord.—It is obvious that radical removal of tumors of the brain and spinal cord becomes necessary to relieve the symptoms of headache, localized pain, and spinal root pain. Brain abscesses must likewise be drained to relieve the symptoms of intracranial pressure. The pains produced by meningitis are usually controlled by spinal fluid drainage and by the administration of antibiotics and the sulfonamides.

Protruded Intervertebral Disk.—The terms "lumbago," "sacroiliac disease," and "sciatica" have frequently been employed to describe low-back pain with extension of pain all through the sciatic nerve.[15] Although inflammatory lesions of the muscles and bony joints occur, a condition known as a "protrusion of the intervertebral disk" is often responsible for the pain. At the onset of symptoms, physical therapy and conservative treatment should be employed. However, with recurring attacks of incapacitating pain, a protruded disk must be suspected as the cause of the pain. Differential diagnosis and removal of the protrusion, if diagnostic findings suggest its presence, are then required.

Anginal Pain.—Angina may result from vasospasm or sclerotic changes in the coronary arteries or a combination of the two which produces ischemia of the cardiac musculature.[16] Internists and cardiologists prefer to control this pain by medical regimens. Some physicians hold that interruption of nerves conducting pain sen-

15. Love, J. G., and Camp, J. D.: Root Pain Resulting from Intraspinal Protrusion of Intervertebral Discs: Diagnosis and Surgical Treatment, J. Bone & Joint Surg. **19**:776-804 (July) 1937.

16. Lindgren, I., and Olivecrona, H.: Surgical Treatment of Angina Pectoris, J. Neurosurg. **4**:19-39 (Jan.) 1947.

sations destroys the patient's danger signals; thus, the patient may attempt to perform physical tasks beyond his endurance and succumb suddenly. However, removal of the upper fourth or fifth thoracic ganglia, which interrupts the sympathetic fibers carrying vasomotor control to the coronary arteries, has proved of value and is indicated for younger persons. Once sclerotic changes have developed in the coronary arteries, medical regimens including vasodilating drugs fail to control angina pectoris. Neurosurgical procedures then are sought for relief. Since the physical reserve of patients with angina is below normal and often life expectancy is limited, a palliative procedure is warranted. The one of choice is a paravertebral alcohol injection of the upper four thoracic nerves on the left side. A similar injection on the right side also may be indicated. The injections can be repeated. If the patient's physical condition will endure an operative procedure, rhizotomy of the sensory roots of the same nerve can be performed. Sympathectomy of the upper thoracic trunk also has been employed with reasonable success. The mortality rate accompanying these procedures is necessarily high.

Causalgia.—This is characterized by burning sensation with profound hypersensitiveness of the area. It follows crushing injuries of the extremities, chiefly of those tissues supplied by the median nerve.[17] The reason for the pain is not too clearly understood, but apparently it is due to a vascular condition—vasospasm or ischemia of the tissues—since cervicothoracic preganglionic or postganglionic sympathectomy relieves the pain in most instances.

Painful Stumps.—Stumps are painful in about 10% of amputated extremities. In a few instances, a neuroma is actually present in the scar at the level of the amputation.[18] Removal of the neuroma and division of the nerve at a level above that of the amputation gives satisfactory relief from pain.

The real problem is that of the patient who after amputation is unable to wear a prosthesis because of a painful stump, even though the surgeon is unable to palpate a neuroma. If by chance the patient also complains of a phantom extremity, the problem becomes still more complicated. If the patient is carrying on a gainful occupation, chordotomy may give some relief. Nerve sections, injections of alcohol, sympathectomies, or rhizotomies are futile. Psychiatric advice may help the patient accept his discomfort, since one of the factors responsible for the development of this group of symptoms has been environmental influences present at the time of the injury. If the patient who complains of a painful stump or a phantom limb is unable to work and is addicted to narcotics, the situation is almost hopeless. The only procedure that may offer assistance to the withdrawl of narcotics is a prefrontal lobotomy.

Raynaud's Disease, Thromboangiitis, and Thrombophlebitis.—Pain of Raynaud's disease and the spasm of collateral arteries in the presence of thromboangiitis obliterans and endarteritis obliterans are relieved by extensive sympathectomy interrupting rami carrying vasomotor stimuli to the arteries supplying the involved extremities. Resection of the sympathetic trunk with removal of ganglia has proved

17. Crawford, A. S.: Medullary Tractotomy for Relief of Intractable Pain in Upper Levels, Arch. Surg. **55**:523-529 (Nov.) 1947.

18. White, J. C.: Painful Aneurysms of the Aortic Arch: Relief by Paravertebral Injections of Procaine and Alcohol, J. A. M. A. **99**:10-13 (July 2) 1932. White.[8]

more effective than periarterial sympathectomy. Alcohol injection has been employed in lieu of the sympathectomy for the same diseases but does not give as complete relief. The injection of the lumbar sympathetic trunk has given some temporary relief when the pain was due to thrombophlebitis.

Dysmenorrhea.—Resection of the superior hypogastric plexus of Havelock (a presacral sympathectomy) has offered relief to many patients with so-called idiopathic dysmenorrhea.[19]

Visceral Pain.—The sensations of visceral pain apparently follow afferent fibers which are associated with sympathetic rami until they reach the nerve roots from which the rami have taken their origin. From that area they enter the sensory roots and the dorsal ganglia of spinal nerves. This fact being true, it is possible to obliterate pain that results from pancreatic calculi and fibrosis of the pancreatic gland by resection of the splanchnic nerves,[20] or preferably the lower thoracic and upper lumbar sympathetic chain together with the splanchnic nerve.

Malignant Lesions.—Neurosurgical procedures are not employed to relieve pain for primary malignant lesions until every attempt has been made to remove the neoplasm or control the primary or metastatic lesions by irradiation therapy.[21] We should like to reemphasize the point that rhizotomy, chordotomy, or tractotomy should not be resorted to if analgesic drugs control pain, and further that the administration of narcotics is justified if the life expectancy is only a few months. It should also be remembered that castration with the administration of stilbestrol is effective in controlling the progress (growth) of certain malignant lesions of male patients, and administration of testosterone and irradiation of the ovaries have a similar effect on certain malignant lesions of females.

Rhizotomy of the fifth and ninth cranial nerves and rhizotomy of the sensory roots of the upper cervical nerves are employed to relieve pain due to primary malignant lesions and metastatic lesions of the mouth, face, pharynx, and cervical regions. Rhizotomy of the sensory roots of the brachial plexus has been employed for metastatic lesions of the axilla and brachial plexus. However, a high cervical (first cervical cord segment) chordotomy is more effective in relieving pain for this area than is the rhizotomy.

Painful inoperable and metastatic lesions of the legs, pelvis, spinal cord, or spinal column below the diaphragm and abdominal cavity are amenable to high thoracic (first thoracic cord segment) chordotomy. Occasionally unilateral chordotomy suffices, but more often than not bilateral chordotomy is required.

COMMENT

Although interruption of sensory nerves and tracts obliterates painful sensations, the patient must be informed prior to operation that anesthesia must be accepted in lieu of pain.

---

19. Adson, A. W., and Masson, J. C.: Dysmenorrhea Relieved by Resection of Presacral Sympathetic Nerves, J. A. M. A. **102**:986-990 (March 31) 1934.

20. de Takats, G.; Walter, L. E., and Lasner, J.: Splanchnic Nerve Section for Pancreatic Pain, Ann. Surg. **131**:44-56 (Jan.) 1950. Craig and Adson.[2b]

21. de Guitérrez-Mahoney, C. G.: The Treatment of Painful Phantom Limb: A Follow-up Study, S. Clin. North America **28**:481-483 (April) 1948. Scott, M., and Wycis, H. T.: Survey of the Value of Neurosurgical Treatment for the Relief of Intractable Pain, Am. J. Surg. **77**:718-736 (June) 1949. Weddell, G.; Sinclair, D. C., and Feindel, W. H.: An Anatomical Basis for Alterations in Quality of Pain Sensibility, J. Neurophysiol. **11**:99-109 (March) 1948.

Relatives of patients who are about to undergo one of the major operations for relief of pain due to a malignant lesion should be tactfully informed that the chordotomy or tractotomy is designed to reduce pain only and is not designed to cure the malignant lesion.

DISCUSSION

Dr. Wallace P. Ritchie, St. Paul: Dr. Svien has very properly emphasized personality changes in prefrontal lobotomy for the relief of pain. This certainly can stand reemphasizing because of the increased demand for this procedure throughout the country, and I don't feel that these personality changes have been properly emphasized to the family and the physicians. It is all very well to do a prefrontal lobotomy in patients who have had some previous personality disease, because anything in such a case is usually an improvement, but in a patient who has no personality changes it is very difficult to return the patient to his family, particularly if he is apathetic and lackadaisical and with very little emotional reaction when he wasn't that way before the prefrontal lobotomy. We use the procedure, but before it is performed the patient's family and the patient himself should be given the worst prognosis. The patient's parents should be told that he will not be himself, that he will be apathetic and unemotional. They have to accept the procedure on that basis, and if they will accept it on that basis, then prefrontal lobotomy is a very excellent way of relieving pain.

Dr. Harry B. Zimmermann, St. Paul: This discussion is directed to the general surgeon. I should like to leave with you a warning from something that happened in my experience. I saw a patient who three years before had had a prefrontal lobotomy done. She had been doing quite well, was able to do her own housework and look after her family. Four days before I saw her she began to refuse her food and to look bad; she had no pain, in fact she had a sense of euphoria, but wouldn't eat.

When I saw her she was in circulatory collapse, had some slight abdominal distention, no rigidity, no tenseness. A flat plate of the abdomen showed an enormous amount of gas beneath the diaphragm. She never recovered from her circulatory collapse sufficiently to be operated upon. She died. The autopsy showed a diffuse peritonitis that had been present at least four days, and a perforation of the anterior wall of the duodenum.

I think one has to be extremely careful about these people who have been operated upon for relief of pain or psychopathic disturbance, and keep in mind that pain is an important diagnostic aid.

Dr. David L. Reeves, Santa Barbara, Calif.: I found Dr. Svien's paper very interesting. He certainly covered the field very quickly and very completely. There were a few thoughts which occurred to me that I wish to mention.

First of all, I don't believe there is anything more difficult to control than postherpetic pain. It has not been our experience that alcoholic injection is very successful, nor have we found rhizotomy very helpful. The most effective results have been achieved by means of early x-ray therapy and sympathetic block. The employment of some of the antibiotics has been useful.

Not too infrequently the injection of the sympathetic nervous system with alcohol leads to a troublesome neuritis.

What Dr. Zimmermann had to say about sympathectomies for the relief of pain masking symptoms certainly is very timely, particularly in sympathectomies for hypertension.

Dr. Hendrik J. Svien, Rochester, Minn.: I just want to thank the discussers for calling to mind and bringing to our attention some of the limitations and the shortcomings of some of these procedures. It is very important that we don't pass them by, and I am very happy that they were brought up.

SURGICAL CARE OF THE NEUROLOGICALLY DEFECTIVE INFANT

JOHN MARTIN, M.D.
CHICAGO

AMONG the large variety of defects of the craniovertebral axis and the central nervous system in infants, many, obviously, because of their very nature could not be improved by any means. Most of the types of craniostenoses are accompanied by primary cerebral developmental defects; porencephaly is a nonreversible situation; the Mongolian infant with its less specific gross neural changes is amenable to no form of medical or surgical care. The dysplasias producing the various spasticities, dystonias, and ataxic states may be aided by specific training measures for the growing child but not by any surgical means applied directly to the nervous system. Additional examples of defects of a nonsurgical nature are commonly recognized.[1]

It is important, however, not to consign all infants with neurologic defects to the category of the hopeless. Specifically, conditions such as hydrocephalus, meningocele (cranial or vertebral), intracranial hematoma or hydroma following birth, and certain neoplasms, after having been diagnosed and estimated by the proper methods, may be so successfully treated that the patient is rendered normal or nearly so. The difficulties of neurological examination of infants are well known to pediatricians, neurologists, and neurosurgeons, and, therefore, to obtain the most complete information before a final opinion is passed, special diagnostic measures are usually necessary. The hydrocephalus may indeed have been present from birth, constantly increasing; the meningocele may be large, excoriated, and weeping; the child may be convulsing in any one of the several patterns; all in all, the child may "not be doing well" from several standpoints. However, these conditions are not reasons for withholding further investigation, for condemning a child to early death, or for, at best, burdening the already defective brain with sedation, either in or out of an institution for the care of such defectives. To do so is to deny comfort and a satisfactory existence to many patients and many parents.

HYDROCEPHALUS

The pessimism of the pediatrician and the despair of the parents are familiar scenes when hydrocephalus is present in the neonatal period. It is readily granted that if a child is born with a large head which rapidly enlarges, if there is good evidence of blindness, deafness, and severe congenital visceral abnormalities, or if

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Nov. 30, 1951.

1 (*a*) Ford, F. R.: Diseases of the Nervous System in Infancy, Childhood and Adolescence, Ed. 2, Springfield, Ill., Charles C Thomas, Publisher, 1944. (*b*) Coleman, C. C., and Troland, C. E.: Congenital Atresia of the Foramina of Luschka and Magendie, with Report of 2 Cases of Surgical Cure, J. Neurosurg. **5**:84-88, 1948.

a large, draining, infected meningocele coexists with a severe degree of hydrocephalus, specific treatment of any nature is precluded (Fig. 1). But a slowly developing nonobstructive hydrocephalus may be present in an otherwise fairly normal child with normal mental potentialities. If the hydrocephalus is confined to the ventricular spaces by obstruction of the aqueduct or by blockage of the points of egress of the cerebrospinal fluid in the posterior cranial fossa, then a different problem exists than in the instance of nonobstructive hydrocephalus. In either event the situation calls for a sufficiently detailed study undertaken in something besides a spirit of defeat.

In addition to a careful history of the prenatal, natal, and postnatal experiences of the child, certain observations in the general physical examination are of much importance. Abnormalities such as extra digits, cleft palate, harelip, clubfoot, imperforate anus, defects of the external genitalia or urinary system, cutaneous lesions, transposition of the heart or other viscera, defects in the optic fundi, and any roent-

Fig. 1.—In spite of a tremendous hydrocephalus and a leaking infected meningomyelocele, this infant, pictured here at 14 days after birth, lived more than 3 months. Surgical treatment was out of the question.

genographic evidence of skeletal abnormality are to be noted. Children with such defects are frequently anemic and, nursing poorly, are chronically dehydrated. Frequent measurement of the head in its greatest circumference must be done and the figures recorded. In the early neonatal period, convulsions are to be investigated rather than conveniently (and usually not very successfully) masked by the use of sedatives.

Nothing gives so much direct evidence of the degree and cause of the anatomic change in hydrocephalus as do the two procedures of ventriculography and "ventricular estimation." They may be performed at the same time, and neither procedure should hurt the patient. Ether with a liberal mixture of oxygen, administered through an endotracheal tube, is the safest anesthetic agent for such an undertaking. Through a small incision on either side of the midline in the posterior parietal region, small trephine openings are made to expose the dura mater, which in turn is opened for inspection of the subdural and subarachnoidal spaces. Immediately, the presence of a hematoma, a hydroma, an extracerebral hydrocephalus, or an

atrophic brain may be determined. The thickness of the brain from the surface of the cortex to the ventricular wall is determined by the passage of the ventricular canulae. The patency of the foramina of Monro is determined by the passage of air from side to side, as in the usual ventriculographic procedure. Then, if a few drops of 0.8% aqueous solution of indigo carmine dye are injected into one ventricle, the scalp incisions may be carefully closed in layers with interrupted surgical silk sutures and the child left upright while a lumbar puncture is performed. If the cerebrospinal fluid pathways are open from the third ventricle through the aqueduct of Sylvius and the foramina of Luschka and Magendie and so into the subarachnoidal spaces over the brain and spinal cord, the fluid appearing on spinal puncture will be tinged with blue. Later, the urine may be studied for the presence of the dye, as a test giving fair evidence of adequate absorptive capabilities of the pacchionian bodies. Roentgenograms of the head will reveal the degree of ventricular enlargment or distortion. In infants it is usually safer and of more general information to perform ventricular puncture directly rather than to attempt pneumoencephalography by the lumbar route.

Detailed description is not necessary to point out that there are in common use several surgical procedures which may be applied for the cure of hydrocephalus.[2] In the brain with nonobstructive hydrocephalus, not hopelessly thinned and distorted, bilateral removal of the chorioid plexus in the lateral ventricles is an operation offering hopeful results (Fig. 2). Unalterable obstruction within the third or fourth ventricle or within the aqueduct may be relieved by creating a permanent fistula in the lamina terminalis and anterior wall of the third ventricle, or by permanently rerouting the fluid by means of ventriculocisternostomy. With either procedure the ventricular fluid is given access to the subarachnoidal spaces over the brain, from which the fluid is normally absorbed. If a tumor is the cause of the obstruction, it should be removed whenever that seems at all feasible. Still other ingenious methods of permanent cerebrospinal fluid drainage are successful. Attempts to open a basilar postinfectious obstruction at the cisterna magna by stripping the leptomeninges usually results in temporary, if any, relief.

INTRACRANIAL HEMATOMA AND HYDROMA

On the basis of grossly demonstrable intracranial pathology, there are many reasons why an infant may convulse, appear anoxic, and otherwise progress poorly during the first few days and weeks after birth. All too frequently one hears the statement that "the convulsions are probably due to cerebral anoxia at the time of delivery," and with that remark further investigation usually ceases, and the administration of sedation is started. As for the investigation of hydrocephalus, ventriculography and "ventricular estimation" give immediate proof of the existence of an intracranial hematoma or hydroma, both of which are surgically curable, with a good prognosis, and neither of which responds to treatment by sedation. Neither of these lesions, which may coexist, or occur bilaterally, or even cover all surfaces

2. Dandy, W. E.: An Operative Procedure for Hydrocephalus, Bull. Johns Hopkins Hosp. **33**:189-190, 1922. Hyndman, O. R.: Hydrocephalus: A Contribution Related to Treatment, J. Neurosurg. **3**:426-443, 1946. Matson, D. D.: A New Operation for the Treatment of Communicating Hydrocephalus, ibid. **3**:238-247, 1949. Matson, D. D.: Ventriculo-Ureterostomy, J. Neurosurg. **4**:398-404, 1951. Putnam, T. J.: Results of the Treatment of Hydrocephalus by Endoscopic Coagulation of the Choroid Plexus, Arch. Pediat. **52**:676-685, 1935. Scarff, J. E.: Treatment of Obstructive Hydrocephalus by Puncture of the Lamina Terminalis and Floor of the Third Ventricle, J. Neurosurg. **2**:204-213, 1951.

of the brain, can be accurately diagnosed as to type and extent, nor can either by any means be totally removed by needle aspiration through a fontanel or open cranial suture (Fig. 3). Such lesions may subtly occur when labor and delivery seemed to have been entirely normal and easy, and, conversely, after a stormy delivery, ventriculography may reveal that the defective infant does not have such a removable lesion but a gross cerebral developmental deformity. With such information, then, a realistic prognosis and course of treatment may be established.

As in the adult head which has suffered trauma, a liquid hematoma subdurally or subarachnoidally located in the head of a child may usually be removed by drainage and irrigation through two trephine openings over the affected hemisphere, or bilaterally if need be. The same procedure may be used to drain a hydroma. Hematomas in infants following birth trauma are the result of venous bleeding into

Fig. 2.—At the age of 2½ years this child was proved by pneumoencephalography to have a communicating hydrocephalus of moderate degree. No treatment was given. At the age of 5 years, when this pneumoencephalogram was made, there was a marked advance in the hydrocephalus. The child was bright, talked well, used the upper extremities well, but was weak and ataxic in the lower extremities. Bilateral plexectomy was performed. Much atrophy could have been prevented by operation when the condition was first realized.

the subarachnoidal spaces. In the fresh state these lesions are softly gelatinous and may be so adherent to the overlying arachnoid or the underlying pia mater that removal through an osteoplastic flap may be necessary rather than by the simpler method of the trephine openings, as just described. The older lesion will commonly be found to have liquefied, producing a lake of slightly viscous fluid, stained to varying degrees by old blood pigment, and with a high protein content. In the older lesions the fluid may be held captive in a sac, the outer layer of which is a thickened, adherent, and often vascularized arachnoid, and the inner layer of which is an inflammatory neomembrane which is adherent to the pia mater. A true hydroma is made up of clear cerebrospinal fluid and exists as a slowly enlarging mass between the arachnoid and the dura mater, finding permanent access with slow seepage through an arachnoidal tear, and probably aided in its entrance into the

subdural space by a pumping valve-like action produced by the pulsations of the brain. The sooner such large space-occupying lesions are removed, the better are the chances that the brain will expand into its normal intracranial spaces, that its normal vascularization may be reestablished with proper oxygenation and growth, that convulsions may spontaneously cease, and that intracerebral gliosis and gross brain atrophy may be avoided.

The use of lumbar puncture in infants under this type of neurological investigation needs careful consideration. It should not be done by an inexperienced member of the hospital house staff. The manometric pressure should always be recorded, the Queckenstedt test should never be done when intracranial pathology is being studied, and every precaution should be taken that the puncture is done without trauma to local subarachnoidal vessels. When fluid is obtained, it may or may not contain old

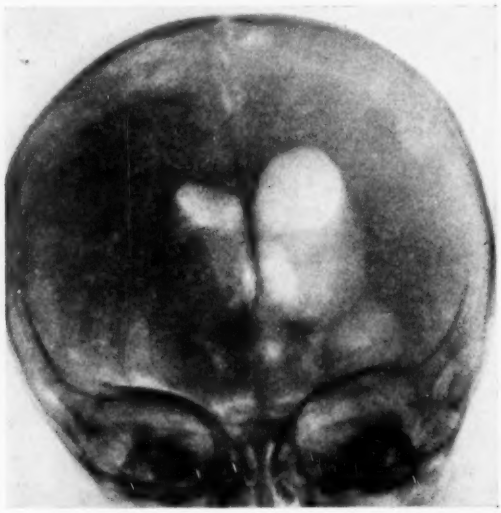


Fig. 3.—Pneumoencephalography revealed moderate cortical atrophy on one side, with a large ventricle on the opposite side where no air entered the subarachnoidal spaces. The third ventricle was shifted to the side of the large ventricle. There was a history of difficult delivery. On the side of the large ventricle an old walled-off liquid hematoma was found and removed at operation. That half of the cerebrum was quite undeveloped. The child convulsed and was moderately spastic on the opposite side of the body. The cerebrospinal fluid on lumbar puncture was entirely normal as to both pressure and analysis. The child was not presented for surgery until the age of 9 months.

blood from the intracranial levels, and if it does give such evidence of previous bleeding, it gives little proof that a hematoma exists. If the fluid is clear, it may or may not have a high protein content, and, in either event, either a hematoma or a hydroma may exist. In short, therefore, lumbar puncture is of very little diagnostic use in determining the presence of an intracranial hematoma or hydroma in an infant.

Occasionally, there is the infant that appears physically normal in every way at birth but, as days pass, continues to nurse poorly, to lose its response to direct light stimulation to the eyes, to lose weight, and to go into a slow decline and prolonged cachexia. It may or may not convulse. The cerebrospinal fluid obtained at lumbar puncture may be entirely normal, but pneumoencephalography may reveal

a small symmetrical brain with a normal ventricular system in a skull of proportions in keeping with the age of the child. Osteoplastic craniotomy will reveal a deep space between dura and cortex filled with cerebrospinal fluid which is entirely normal on analysis. No arachnoid is found underlying the dura, external to the fluid mass. Closely investing the brain on all surfaces, like a tight-fitting molded envelope, is a completely transparent, extremely tough and resilient, cellophane-like membrane which is free of all blood vessels and is not attached to the brain even at the dural sinuses. This membrane, which may exist unilaterally or bilaterally, may be stripped in its entirety from the brain and, since it invests the brain so closely, there is no fluid space between it and the cortex. It is a question as to whether this is the original, now transformed, arachnoid, with a congenitally subdurally placed hydroma, or, as is more likely, whether the entire arachnoid is defective, the fluid being truly a deep subarachnoidal lake and the membrane a developmental anomaly.

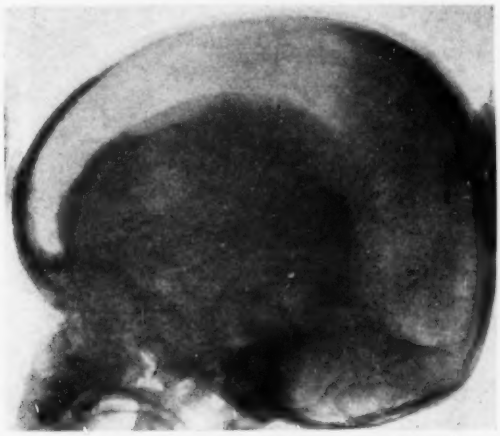


Fig. 4.—Ventriculography revealed in this 2-month-old infant a brain of fetal size in a calvarium of a size proper for the child's age. The brain was encased in an investing membrane much like a cellophane bag. The bulk of the brain was probably not equal to half the space of the intracranial cavity.

The membrane presents on microscopic examination only the appearance of a dense nonspecific and nonvascularized fibrous tissue, sparse in identifiable cells.

Such a membrane mechanically restricts the brain to its fetal size, whereas the calvarium has developed normally (Fig. 4). The necessity for the early removal of such a membrane is obvious, in order that the brain will no longer lag in development but may expand and make up, so to speak, for lost time.

MENINGOCELE

Meningocele occurring at any level along the craniovertebral axis may be complicated by the presence of contained cerebral or cerebellar tissue (meningoencephalocele) or by a displaced extent of spinal cord or cauda equina (meningomyelocele). Such severe defects involving the central nervous system may occur singly, in multiples, or in combinations of the two types of lesions (Fig. 5). Not infrequently other extensive congenital defects of the body are present, and, especially if the meningoencephalocele is severe, the child may die within a few days

after birth. The repair of such a meningoencephalocele in a child that continues to live has little to offer other than cosmetic improvement, and so such surgery is seldom called for.

Ordinarily the presence or absence of neural content within a meningocele can be determined by careful transillumination and gross inspection. These lesions should never be aspirated for diagnosis, nor should contrast media be injected into them. If the child is very young, roentgenograms of the skull and spine may fail to locate with certainty the extent of any discernible skeletal defect. Such a defect may exist at any point from the glabella to the coccyx and should be considered for surgical repair. There can be no rule as to the optimal time for repair, since that must be determined by the condition of the child, the presence of other severe

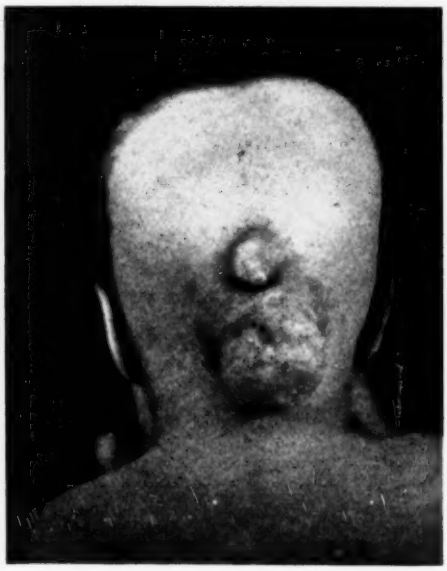


Fig. 5.—A large meningocele protruding from the level of the foramen magnum, with a smaller one emerging through a bone defect just below the lambda. Both are in the exact midline. Note the telangiectatic skin.

and incurable deformities, the urgency of the condition of the skin over the meningocele, and ordinary good surgical judgment. The age of the infant is not of primary importance in such a determination. About the head and neck these lesions may protrude as smooth pulsating masses covered by skin of fairly good quality, or they may be large bag-like pedunculated masses, bruised and abraided during delivery, in which case they present the hypothetical problem of a two-headed fetus (Fig. 6). On the back, at whatever level these lesions appear the skin over the central portion frequently is extremely thin, red, crusted and weeping, and barely containing the cerebrospinal fluid. The surrounding skin is telangiectatic and thickened and without its normal elasticity. Such lesions may vary in size from that of a pea to that of a large potato, ranging from a flat outline to an extremely elevated outline (Fig. 7). Great care is necessary in the surgical dressing of these masses, since soiling by feces or urine is a constant threat, resulting in an almost

certain widespread subarachnoidal infection. Because of the fear of rupture or, indeed, by the very bulk of the mass, the child is restricted to either the ventral or the lateral position in its bed.

Considerable ingenuity must be exercised in the closure of large defects, especially on those of the lower back, since the defective skin must be completely excised and closure made in anatomical layers, with as little tension as possible. Special materials and techniques must be used for the more difficult closures.[3] When at operation over the cervical or thoracic spine the defect is found to contain a humped-up segment of spinal cord or a cord which is grossly deformed or embedded in a scar-like mass of fibrous tissue, there is little to be accomplished other than plastic repair of the meninges and the soft tissues external to them,

Fig. 6.—This large meningocele was bruised and torn during a difficult delivery, and it was removed on the sixth day after birth, when its rupture appeared imminent.

but such soft-tissue repair is entirely justified, regardless of the condition of the cord. In the lumbosacral canal a lesion thought to be a simple meningocele may contain, in the bulging roof and lateral walls of the mass, thinned-out and tangled roots of the cauda equina. These fibers may seem to enter into and become lost in the thinned-out walls of the sac, made up, as it is, of defective meninges, fascia, and skin. When such a condition is found, these rootlets should be gently dissected free, cut from their terminal attachments, and allowed to fall into proper order on to the anterior wall of the vertebral canal. The structures on the anterior and anterolateral walls of the canal appear grossly normal. The filum terminale should always be cut in order to remove any traction it may be exerting on the spinal cord. In other words, genuine neurologic benefit in addition to mechanical

3. Nosick, W. A.: The Repair of Lumbar and Cranial Meningocele with Tantalum Gauze. J. Neurosurg. **5**:540-542, 1951.

plastic repair may be accomplished in such infants if the problem is treated by something more vigorous than thoughts of futility.

It is very gratifying to watch the general improvement in an infant after the removal of such a mass. The state of nutrition invariably improves. Certainly the care of the child is greatly simplified, to the great relief and encouragement of the parents. But more important than any other gain is the fact that after a few weeks or months many such children show improving strength in the muscles of the buttocks and thighs, as well as partial or complete control of the bowel and bladder, when such weakness had existed, as it characteristically does when the cauda equina is involved in the meningocele. As they get older, such children may learn to walk with the aid of braces, together with properly advised surgical orthopedic procedures.

The combination of hydrocephalus and meningocele may be present at birth, or at birth meningocele alone may be evident, the hydrocephalus not becoming apparent

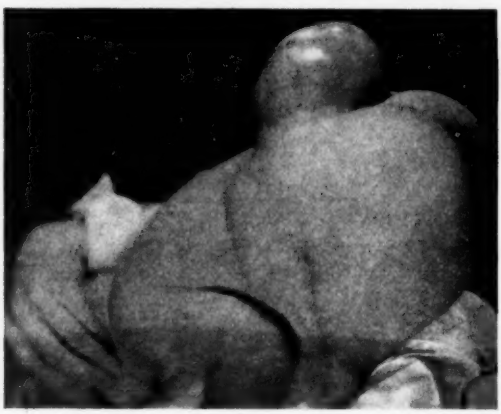


Fig. 7.—The lumbosacral mass in this 8-month-old child was covered by tough rubbery skin, but from two or three tiny sinuses, cerebrospinal fluid leaked intermittently. Five years after operation the child was bright, without any sign of hydrocephalus, with fair bowel and bladder control, and with good use of the buttock and thigh muscles. The ankles and toes could not be moved. Filaments of the lower cauda equina were found in the dome of the mass at operation. An extra digit on one hand was the only other congenital deformity to be found.

until some time thereafter. The two conditions are not, however, dependent upon one another; they may happen to coexist, just as other combinations of congenital deformities of the central nervous system and somatic portions of the body may exist in combination. It is sometimes noted, therefore, when a meningocele has been repaired early in the neonatal period, that hydrocephalus begins to develop in the child, and it is a common pediatric fault to consider the hydrocephalus a result of the repair of the meningocele. Nothing could be farther from the truth. There is no tissue whatsoever within the walls of a meningocele which has any absorptive property for the cerebrospinal fluid. True, in a child with essential hydrocephalus and a leaking meningocele, the latter acts as a constant drain and the head will only slowly enlarge should the child happen to live, but the brain, meantime, is defective as it originally was, and its development will fail or progress within the limits of its original inherent potentialities, regardless of the presence of any meningocele.

OTHER CONDITIONS

Unfortunately, many tumors of the brain in infants and children are malignant to varying degrees and the results of treatment are usually only palliative or temporary. However, benign tumors do exist, typical examples of which are the various types of dermoid and teratoid masses, not tumors in the true sense of that word but, nevertheless, space-occupying and destructive. Fortunately, they are often removable, with good results. Actual removal of an obstructing tumor from the region of the third ventricle or aqueduct is usually either impossible or fraught with such danger that more conservative methods to relieve the obstruction must be sought.[4] Likewise, in the presence of a congenital atresia of the aqueduct the

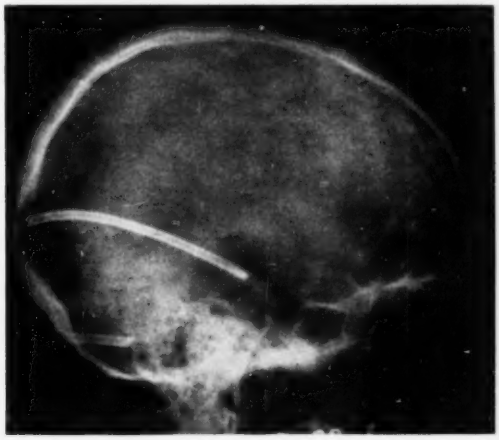


Fig. 8.—Lateral view of skull with permanent ventriculocisternostomy. Tube is an ordinary No. 8 French rubber catheter. It passes from the temporal horn of the ventricle back through the body of the ventricle, the occipital horn, the occipital lobe, and a small trephine opening in the occipital bone to the side of the midline. From there it passes under the galea and enters the cistern magna through a second trephine opening near the midline of the bone just above the foramen magnum. The third ventricle, the aqueduct, and the fourth ventricle are thus bypassed.

obstruction may be relieved by third ventricular ventriculostomy or by ventriculocisternostomy, as already mentioned in the treatment of hydrocephalus from other causes (Fig. 8). Several cases are on record of the successful surgical cure of the congential absence of the foramina of Luschka and Magendie, which had caused a congenital obstructive internal hydrocephalus.[1b]

CONCLUSIONS

The young infant is difficult to estimate accurately and completely in a neurological sense, and it may be several weeks or months after birth before a correctable defect of the central nervous system, present since birth, is suspected. The infant that convulses and otherwise fails to thrive though it shows no outward signs of neurological deficiency must not be treated with a blanket of sedatives or regarded with a convenient attitude of hopelessness on the part of the physician. As in any

4. Torkildsen, A.: Should Extirpation be Attempted in Cases of Neoplasm in or Near the 3d Ventricle of the Brain? Experiences with a Palliative Method, J. Neurosurg. **3**:249-275, 1948.

other situation in an infant or an adult, a diagnosis must first be made before either treatment or probable prognosis may be established. Such presenting lesions as hydrocephalus and meningocele must be courageously and realistically approached, especially since in the infant the nervous system is not yet completely developed and the element of time aided by good surgery offers hope for improvement to a degree which can never be determined at the time of treatment. To overlook such a curable lesion as a hematoma or hydroma is rarely excusable. If, after diagnosis, a hopelessly severe congenital defect, be it of neurological nature or otherwise, is found in an infant, then at least a rational plan may be followed for its future care. Certainly, to make no attempt to help the child is to expect no improvement.

DISCUSSION

Dr. David L. Reeves, Santa Barbara, Calif.: Dr. Martin has related a number of interesting problems. I can only say, however, that I wish the results surgically were more encouraging. Many of the infants who have a myelomeningocele in association with a spina bifida have other congenital defects. Hydrocephalus develops with distressing frequency. While we must bend our efforts toward reconstruction and repair, my own experience has revealed the over-all results as disappointing.

Dr. Martin has also emphasized the importance of institutionalizing the defective child. While it is easy to advise the parents to do this, few of them are inclined to accept the advice.

Time probably precluded the mention of another congenital abnormality of infants, and that is the premature synostosis of the bones of the skull, preventing the normal growth of the brain. In general, surgical intervention here has been more gratifying than that performed for other anomalous conditions. Faber and Towne, of Stanford University School of Medicine, were among the first to show that linear craniectomy would relieve the abnormality. Some outstanding work in this respect from the Children's Hospital in Boston has been published. Formerly, many infants became blind and remained mentally retarded.

It is surprising how long it has taken not only the pediatricians but also the neurosurgeons and the general surgeons to appreciate that information.

I will close by mentioning one case of a congenital porencephalic cyst of the left parietal region, associated with an overlying skull defect and a right hemiparesis. Because his scalp was so sensitive, this little boy refused to have his head touched. I had never seen a situation of that sort before. We repaired the skull defect with a tantalum plate, and the child was completely relieved of the horror of having his head touched. Although he was still a right-handed paretic, this little boy was sent back to his family happy and more easily controlled.

Dr. John Martin, Chicago: I should like to mention the matter of the development of hydrocephalus following the repair of a meningocele at any point.

It is most important to realize that the actual facts are that a wall of a meningocele has no absorptive powers. Of course, a weeping meningocele does act as a safety valve, and with such a lesion, hydrocephalus might never develop or might be slow in developing, but the proclivity of the person's anatomy either is or is not such that hydrocephalus will develop regularly in the presence or absence of a meningocele. I have too many patients in my series who have had both dry and weeping meningoceles removed and in whom hydrocephalus has never developed later to believe that hydrocephalus must necessarily follow the removal of a meningocele.

I have also seen too much neurologic improvement in these children and too much gratification on the part of the parents to be relieved of the burden of a child with such a deformity to believe they should be neglected and considered lost cases. It is perfectly obvious, as I pointed out, that some of the lesions are not repairable and may be combined with other somatic or physical type of congenital deformity.

My principal plea is that these unfortunate subjects not be neglected, but that at an early date every effort be made to give them the benefit of a complete and careful diagnosis, and that the attending physician have the courage to try to do whatever might be possible to give them some increased measure of anatomical and physical efficiency, since one has so little to use when dealing with these dreadful lesions.

MANAGEMENT OF LARGE CONTAMINATED WOUNDS

HARVEY S. ALLEN, M.D.
CHICAGO

RECENT improvements in therapy for traumatic shock have enabled many seriously injured patients with complicated wounds to survive the immediate injury. Treatment of shock has become generally accepted, and the physiological requirements of each patient are better understood and supplied. The recent writings of Beecher, Snyder, and others have spread this information.

Although it is now possible to survive the shock state, yet many seriously injured patients are seen late with neglected open contaminated wounds, a large number of which are infected. It is inconsistent to properly care for the shock state of these patients and subsequently ignore other factors equally necessary for their complete and successful recovery.

A too common example of neglected open infected wounds has been those of the burned patient. The usual story has been survival from the burn shock, followed by a prolonged period of waiting and of hoping for spontaneous closure of the whole-thickness burn. However, the same situation is now being seen in patients with soft-tissue wounds, some with simple but extensive skin loss, others with complications such as fractures or exposed bones. The late phase in the management of these patients is deficient. In cases in which large soft-tissue defects were present, either the wounds have been left open initially and then closure unnecessarily delayed, or haste in caring for the patient at time of the injury has influenced the judgment of the surgeon, and nonviable skin has been left which has become infected.

Actually, it is not easy to outline a step-by-step program for the treatment of each individual wound, yet the principles of care for any open traumatic wound remain the same. Regardless of the size, location, or complicating factors, it is imperative to convert the open contaminated wound into a closed wound as early as is possible and practicable for the patient.

It is because the surgeon fails to have an outline or plan of attack that more and more of these patients are seen late exhibiting signs of deterioration owing to the presence of the open wounds plus the factor of infection. Although they are well cared for initially in the shock state and have survived this phase, these patients are allowed to remain stagnant, and little active surgical care is given the wounded area aside from repeated applications of various drugs or administration of antibiotics. This is not meant as a plea to the surgeon to neglect the general shock state of the patient in order to give the wound more meticulous care; however, wound excision, regardless of where performed, must be done efficiently, that is, all foreign material and dead tissue must be removed—there can be no compromise.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Nov. 30, 1951.

It is granted that the concept of surgical excision or débridement is widely disseminated, yet it has occurred to all surgeons that this procedure is often abused, for either too much or too little excision is performed, and both these factors will unquestionably influence closure of the wound, whether primary or delayed. Primary closure of large complicated traumatic wounds is not always possible when associated with serious shock. When such is the case, delayed closure is wise and reflects the surgeon's judgment, for few can possibly object to delayed closure of a wound under these conditions.

However, if the large soft-tissue wound has been allowed to remain unclosed after the immediate surgical excision, it is the surgeon's responsibility to convert this area into a closed wound as soon as the patient can tolerate such a procedure. Delay beyond 3 to 10 days is rarely indicated, for after this period, the wounds frequently become infected, thus adding another complicating factor to management. Also, as a result of delay beyond this time, the patients' ability to heal correctly is greatly disturbed. Patients exhibit marked signs of secondary anemia, loss of appetite, weight loss, and, understandably, loss of morale.

One of the common errors seen in treating this type of patient is the attempt initially to replace skin and subcutaneous tissues which have been seriously crushed, as in automobile accidents and industrial injuries. It requires considerable judgment to decide what portion of skin will survive after it has been torn, crushed, and contused, and it is not an easy problem for even experienced surgeons to assess the viability of this skin. Possibly one reason that surgeons attempt to salvage even nonviable tissue is because the early precarious state of the patient seems to warrant their haste in débriding and closing the wound.

REPORT OF CASES

Case 1.—L. S., a 17-year-old white girl, was brought to Passavant Memorial Hospital on June 7, 1950. Twenty-eight days before she had sustained a severe injury to her right leg when she was thrown from a motorcycle in the path of a large trailer-truck. The patient was taken to another hospital in a condition of shock and immediately given blood and plasma. She received 1,000 cc. of plasma and 1,000 cc. of whole blood during the first 20 hours. Examination at the time of arrival revealed marked injury to the right lower extremity. It was reported that there were extensive lacerations of the skin of the right lower leg, extending from the upper thigh across the knee and down to above the ankle joint. This skin and subcutaneous tissue had been avulsed from the muscle layers, and lay loosely about the leg, attached only at the upper and lower ends of the laceration. Four hours after admission the patient was in a sufficiently satisfactory condition to enable the surgeon to cleanse the wound, débride it, and suture the seriously contused skin into place. At the time of the procedure it was noted that the circulation of the skin was questionable. X-rays revealed a fracture of the mid-third of the right femur and of all four pubic rami. Gross bloody urine was obtained by catheter, but there was no subsequent evidence of bladder or urethral damage. Because of the fractured femur, skeletal traction through the tibial tubercle was applied. Traction was maintained with the femur at right angles to the pelvis. The patient was given tetanus and gas gangrene antitoxins, N. F., penicillin, streptomycin, and sulfonamide drugs. The patient showed a marked toxic reaction during the first days, with temperatures ranging from 101 to 104 F., subsiding to 99 to 102 F. in the second week, and later ranging from 101 to 104 F. At the time of the first dressing, five days post injury, it was apparent that there was extensive necrosis of the skin of the right leg. Débridement was begun and all the dead skin was removed. An abscess formed just below the inguinal region and this demanded incision and drainage. When admitted to Passavant Hospital four weeks after the injury, the patient exhibited marked signs of infection and associated secondary anemia and a hypoproteinemia. The blood count showed

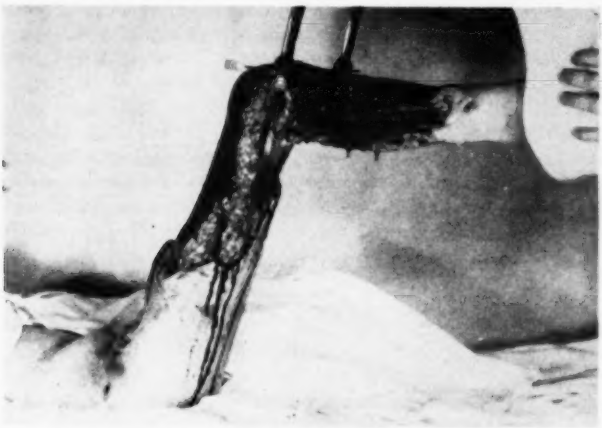


Fig 1 (Case 1).—Appearance of patient's leg five days after her admission to Passavant Memorial Hospital. There is the wide loss of skin and subcutaneous tissues from the lower third of the lower leg to the upper third of the upper leg. Moist compression dressings have provided a firm flat granulating base ready to receive skin.

Fig. 2 (Case 1).—Patient's leg one year later. Sensation in the foot has not completely returned and the orthopedic division is contemplating further work to the knee area.

3,000,000 red blood cells, 9 gm. of hemoglobin, and a hematocrit reading of 33%. Examination of the right leg, still in traction, revealed complete loss of skin from above the ankle, extending up to the upper third of the thigh. The tibia was exposed over the crest and the knee joint was opened on the medial aspect. The foot was anesthetic, but circulation was excellent. There had been a complete loss of the quadriceps attachment to the knee. There was a profusely draining wound below the right ilium and two stab wounds on the dorsum of the thigh which had been established for drainage. Culture of the wound revealed sensitivity of the bacteria to streptomycin and penicillin. Blood cultures revealed no pathogens. The patient's temperature ranged from 99 to 103 F. Immediate attention was directed to correcting the patient's general condition both by dietary methods and by giving the required amount of whole blood. Sterile moist dressings with moderate compression were applied daily.

Fig. 3 (Case 1).—Patient's leg one year later. Sensation in the foot has not completely returned. Additional treatment to the knee area is contemplated.

Five days after admission the patient was taken to the operating room and under general anesthesia, with traction still in place, the entire area was completely covered with a skin graft. This procedure was done with the aid of two whole blood transfusions at the time of surgery.

Fully 85% of this graft took, and the patient's temperature response was very marked; for the next week it did not exceed 101 F. and thereafter was normal. Postoperatively traction was maintained, and three weeks later the small areas that had not been covered with skin were again grafted and this successfully covered the entire leg. After this procedure, on

July 14, a hip spica was applied by the orthopedic service, and the patient was then allowed up on crutches. The femur had subsequently united and the sensation of the foot was slowly returning. The orthopedic surgeon was considering a knee fusion for this patient.

The traumatic wound demands initial careful excision of only the devitalized tissue, whether skin, muscle, or bone. When practical, many large wounds can be closed primarily, possibly with a combination of suture and skin dressing, or grafting.

The failure to close these large wounds later may be traced to the size of the wound itself, as it appears too formidable for closure. However, "staged" closure by skin dressing can and should be performed.

Because of complicated wounds such as fractures or other injuries, frequently these wounds are allowed to remain open. However, closure of the wound, even as a delayed procedure, will successfully prevent the possibilities of infection occurring.

Fig. 4 (Case 2).—Appearance of the patient's wound at the time of delayed secondary closure by skin grafting one week after injury. There was laceration of the skin of the scrotum and also of the anus. There was no infection to be combated owing to accurate surgical excision at the time of initial care.

Case 2.—K. B., aged 6 years, was admitted to Cook County Hospital seven days post injury. On Jan. 22, 1951, this patient sustained a traumatic amputation of the left lower extremity at the hip joint. He was taken to another hospital, where the shock state was adequately corrected and treated. Three hours after injury he was taken to the operating room and the wound was thoroughly débrided. The following condition was reported: There was complete amputation, with 1 in. (2.5 cm.) of the neck of the femur remaining. The skin of the scrotum and of the anus had both been widely torn. The rectum had not been injured. After débridement, a large compression dressing was applied, and the patient's blood levels were carefully checked and restored to normal. The patient was admitted to Cook County Hospital, Jan. 29, one week following injury. Examination revealed blood counts at a high level with a hematocrit reading of 45%; hemoglobin, 14 gm.; protein level, 6.3 gm. per 100 cc. with a normal albumin-globulin ratio. Examination revealed a clean wound of the amputation stump. This defect extended from the level of the anterior iliac crest to the level of the posterior at the crest and medially to the scrotum and to the anus itself. Three days after admission,

with the patient under general anesthesia, this entire area was accurately closed by the use of a skin graft. The patient was given penicillin for one week postoperatively and was given during his hospital stay one unit of blood. The first day postoperatively the temperature did not exceed 101.6 F., and thereafter it was normal. The local wound healed very kindly except beside the anus. It took three and one-half weeks for this area to close in satisfactorily. At no time was there any problem of infection or any nutritional changes to be combated.

The burned patients, likewise, present a phase of this same problem. Because of improved methods of approach to burn shock, patients with really extensive skin involvement are surviving. Removal of the burn slough leaves hugh soft-tissue defects which must be closed by skin grafting. Often "staged" grafting and occasionally even hemografting may be lifesaving procedures, but it makes little difference whether the wound resulted from a burn or from some other injury, the management of the patient and of the wound is the same.

Fig. 5 (Case 2).—Appearance of the wound six weeks postoperatively. By converting this into a closed wound early (within 10 days after injury) infection and nutritional changes which would naturally follow this large wound have been avoided.

Unfortunately, there are instances when these large wounds have become infected, and in such a predicament there must be no delay in providing these patients with intelligent surgical care. It is imperative to maintain the patient's general condition at a high level by proper diet and blood replacement. Early correct removal of the infected skin and subcutaneous tissue is likewise indicated. The antibiotics should not be used too freely, and their specificity should be checked by culture and sensitivity tests to determine the drug which will be of aid to the surgeon. Where frank infection has occurred, daily aseptic care to prepare the wound for closure must be employed. Usually it is possible after four to six days of such treatment to improve the wound and have it in readiness for closure by skin grafts.

Case 3.—C. B., aged 10 years, was admitted to Cook County Hospital on March 30, 1951. Four weeks previously he had suffered a very severe burn when his shirt caught fire. Immediate treatment at another hospital consisted of cleansing the wound, applying a large compression dressing, and correcting burn shock. Twenty-four hours after the injury it was reported that

because of marked vascular change in the left hand, part of the brachial muscles and the pectoralis muscles were completely removed and a fasciotomy was performed on the arm and forearm. The patient was given a continuous stellate block. Four days after injury a dorsal cervical sympathectomy was performed.

The patient was admitted to Cook County Hospital in a marked debilitated septic state. The temperature reading was 102.4 F.; hematocrit 31%; total proteins 5.3 gm. with a reversal of the albumin-globulin ratio. Examination of the wound revealed a very severe burn, extending from the base of the left hand, completely encircling the left upper extremity, extending on to the neck, and posteriorly to the spine, anteriorly to the midline, and inferiorly to the level of the pelvis. The left forearm and arm had large necrotic areas of tissue remaining on them and the entire wound had a foul odor and a very moist glistening appearance. The capsule of the left shoulder joint was visible in the wound. The immediate concern was restoring the general state of the patient by dietary means and by repeated whole blood transfusions. Daily, sterile moist compression dressings were applied, and débridement of the wound was performed. The blood count and chemistry values immediately responded, and one week after admis-

Fig. 6 (Case 3).—Extent and gross appearance of infected burn four weeks after injury. Necrotic material is still adherent at the level of the wrist, the upper arm, and the chest wall. By cleansing the wound daily and by restoring the patient's nutritional and blood levels to normal it was possible to close this wound by skin grafting one week after admission.

sion the entire area was covered with split-thickness skin grafts. There was an immediate response, the temperature subsided, and the patient's nutritional state immediately improved. The wounds were entirely healed by the end of May, eight weeks after admission, but the patient then had very poor motion at the elbow and wrist. A great amount of additional therapy will be required for this patient.

Where exposed bone is in the depths of the wound, it is still necessary to close the soft-tissue defect up to the site of the exposed bone, for this will prevent further loss of tissue, fluids, and proteins, and will greatly minimize the possibilities of infection developing. After the wound has been closed up to the exposed bone or fracture, sequestration of the osseous tissue will occur more rapidly, and skin grafting to this bony defect can then be accomplished. The approach to the problem of earlier wound closure will require techniques used in various fields, such as orthopedics, plastic surgery, or other specialties; yet the well-trained general surgeon should be aware of the use of these methods and apply them whenever

necessary. The size, extent, or anatomical location of the wound should not be a reason to delay closure, nor should associated injuries be cited as excuses. The principles of wound management remain the same regardless of these factors.

It is perhaps the fault of our teaching that this aspect of the problem of late closure of wounds is approached with neither the vigor nor the understanding which is necessary for correct treatment. Surgical residents on active trauma services are fully aware of the method for treating shock states, but their inability to project an outline of treatment for extensive, complicated, or infected wounds is sadly lacking, and it is undoubtedly our responsibility to outline this treatment.

Therefore, in order to emphasize its importance again, it may be well to conclude with the thought that intelligent efficient management of badly burned or wounded

Fig. 7 (Case 3).—Showing more detail the natural narrowing of the burned area. There is very poor motion of the shoulder, elbow, and left wrist, which will require later care.

patients must not only begin with the shock state but must be carried through all aspects of care, embracing the other factors herein mentioned as well for they are equally significant, and must be observed if the maximum result is to be obtained.

DISCUSSION

DR. MICHAEL MASON, Chicago: I should like to say just one word because this is a difficult group of cases to handle, and Dr. Allen has shown a few examples of some of the severer cases. The point I should like to make and to emphasize in the immediate care of a wound of this type or even in a less extensive one is that many times knowledge of the nature of the traumatizing agent is of great help to the surgeon in carrying out a primary wound excision. If he knows that the skin and muscle are badly crushed and damaged, even though it may look satisfactory, he can be fairly sure that the tissue is going to become necrotic. It may or may not appear to have been subjected to a severe crushing injury, but if we know it has been badly damaged we know it probably will die. That is something to remember and something which has been very helpful to us in making a primary excision.

NONUNION OF THE NECK OF THE FEMUR

Study of Three Hundred Forty-Seven Cases

H. B. BOYD, M.D.
MEMPHIS
AND
H. H. BRINDLEY, M.D.
TEMPLE, TEXAS

IN THIS study 347 cases of nonunion of the neck of the femur seen at the Campbell Clinic from 1918 through 1949 were reviewed. Nonoperative cases as well as operative cases were analyzed. It was thought that a statistical analysis of the nontreatment group would be of value not only from a simple informative standpoint but also as a basis for comparison with the treated group.

The cases were classified in four groups on the basis of results: excellent, good, fair, and poor (Table 1). Those classified as excellent or good were considered satisfactory, while cases in the fair and poor groups were considered unsatisfactory. In the fair group partial weight could be borne on the affected limb. However, the hip function was usually limited and painful, and the x-ray findings were generally poor.

We were able to classify 277 cases. In 120 cases no treatment was given; in 157 some type of operation was performed.

NONTREATMENT GROUP

The percentage of patients that obtain a good or excellent status without treatment is small (Table 2). Only 22, or 18.3%, of the 120 patients classified in this nontreatment group had a good or excellent rating. These 22 patients had little or no disability, and several of them have managed well for over 10 years with a nonunion of the neck of the femur. They required no treatment. Except possibly for some young patients, those with nonunion but satisfactory function should probably not be operated on. Also, in very old and debilitated patients, operative repair usually should not be attempted, regardless of the status of the hip. Still, 81.7% of patients in the nontreatment group had unsatisfactory hip function, and, since the average age of patients in this group was only 62.5 years, apparently most persons with nonunion of the neck of the femur are entitled to some type of operative treatment.

Dr. Boyd is from the Campbell Clinic.

Dr. Brindley is from the Scott and White Clinic.

From the Campbell Foundation and Orthopedic Department, University of Tennessee Medical School.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Dec. 1, 1951.

TREATED GROUP

The operative cases were divided into four main groups as follows: (1) those of arthrodesis; (2) those of reconstruction; (3) those of osteosynthesis, and (4) those of osteotomy. The various operative procedures in each group were also studied separately. This formed a definite basis for determining in which of the operative procedures the best results were obtained.

TABLE 1.—*Summary of Results*

Excellent	
1—Walk without support	
2—Little or no pain	
3—Slight limp	
4—3+ or 4+ range of motion (except for fusions)	
5—Not over 1½ in. shortening	
6—3+ or 4+ activity	
7—Structures good as seen with x-rays	
Good	
1—Walk with cane	
2—Slight pain	
3—Slight or moderate limp	
4—2+ or 3+ range of motion	
5—2+ or 3+ activity	
6—Structures good as seen with x-rays except	
a. Nonunion of fracture in McMurray osteotomy	
b. Mild degenerative changes in head	
Fair	
1—Only partial weight bearing with crutch for support	
2—Moderate pain	
3—Moderate to severe limp	
4—1+ or 2+ motion	
5—1+ or 2+ activity	
6—Structures poor as seen with x-rays	
Nonunion and degenerative changes as long as function is fair	
Poor	
1—Ambulatory only with two crutches or confined to wheel chair	
2—Limited painful motion	
3—Structures poor as seen with x-rays	

TABLE 2.—*Patients Receiving No Treatment*

Total no. of patients		150
Classification:		
Able to classify		120
	4, or 3.3%, excellent	
	18, or 15.0%, good	
	27, or 22.5%, fair	
	71, or 59.2%, poor	

ARTHRODESIS

Arthrodesis was attempted in seven patients (Table 3). Five patients had an adequate follow-up for classification. Only one obtained a solid fusion; this patient had an excellent result. The other four had unsatisfactory results; two, fair results, and two, poor. One patient died on the seventh postoperative day.

a mortality of 14%. All patients in this group had spica cast immobilization for a longer average period than in any other group. The average hospital stay was longer in this group than in any other.

This is a small group of patients, and hence no definite conclusions can be drawn. However, when only one patient out of five obtains a satisfactory result, the procedure seems of doubtful value, especially when one considers that 18.3%, or almost one out of five, of the untreated patients had satisfactory hip function. Occasionally, there may be a patient with nonunion of the neck of the femur in whom an attempt at arthrodesis is justified, but this is apparently rare. The other operative procedures offer much better results.

RECONSTRUCTION

A Whitman type reconstruction was carried out in 40 patients. We were able to classify 35 of them. Nineteen patients, or 57.6%, of those classified obtained satisfactory results. Ten of these patients had excellent results. Fourteen patients, or 42.4% of those classified, had unsatisfactory results. Two patients died during convalescence, a mortality of 5%. Compared with the nontreatment group, there was an improvement of 39.3% in the number of patients obtaining satisfactory hips.

TABLE 3.—*Arthrodesis*

Total no. of patients	7
Classification:	
Able to classify	5
1, or 20%, excellent	
2, or 40%, fair	
2, or 40%, poor	

A Colonna type reconstruction was done for two patients. One walked with a cane, had no pain, and had good structures as seen with x-rays. This patient had a good result. The other patient was unable to bear weight on the affected limb and had a poor result. Each patient had only 1 in. (2.5 cm.) of shortening, which was less than most of the other reconstructions. Colonna [1] stated that lessened length discrepancy was one of the advantages of this procedure. Of course, our group is too small to draw any conclusions. Colonna [2] reported a series of 40 cases with 82.5% satisfactory results. Apparently the operation is of value, especially in those cases in which there has been a complete absorption of the neck of the femur.

In one patient, a 35-year-old man, a L'Episcopo [3] type of reconstruction was done. A fracture occurred through the medial fragment articulating with the acetabulum, and thus stability was lost. The case was classified as poor.

Nine patients had an Albee type reconstruction. Seven of them, or 77.8%, had satisfactory results. There were no deaths, complications, or deformities. This group had the best results of any of the reconstruction groups. Of these patients 59.5%

1. Colonna, P. C.: A Reconstruction Operation for Old Ununited Fracture of the Femoral Neck, J. Bone & Joint Surg. **19**:945-954, 1937.

2. Colonna, P. C.: The Colonna Reconstruction for Ununited Fractures of the Neck of the Femur, J. Bone & Joint Surg. **21**:701-709, 1939.

3. L'Episcopo, J. B.: Stabilization of Pathological Dislocation of the Hip in Children, J. Bone & Joint Surg. **18**:737-742, 1936.

more had satisfactory hips than those that received no treatment. This group is also too small to make definite conclusions but it is worthy of consideration. Perhaps lateral displacement of the trochanter is better than distal displacement, as Albee [4] has stated.

Two patients had a Batchelor type reconstruction. One patient had had a previously unsuccessful Colonna procedure; the other had had a previously unsuccessful Whitman operation. The operation in both instances was simply a Schanz pelvic-support type of osteotomy for cases in which the head and neck of the femur were absent and the upper end of the shaft was not articulating with the acetabulum. The operative result was the same as that described by Batchelor [5] and Milch.[6] One of these operations was a failure. The other patient had been followed for only eight months, but mechanically the structures looked good as seen with x-ray study; there was a good range of painless motion, and the hip felt stable. We could classify only the one poor result; however, the outlook for

TABLE 4.—*Reconstruction Group*

Total no. of patients	56
Whitman reconstructions	40
Albee reconstructions	9
Shelf, or modified Whitman, reconstructions	2
Colonna reconstructions	2
Batchelor reconstructions	2
L'Episcopo reconstruction	1
Classification:	
Able to classify	48
14, or 29.0%, excellent	
14, or 29.0%, good	
7, or 14.6%, fair	
13, or 27.4%, poor	

the other patient is good. This procedure might prove to be beneficial, especially for those patients who have had a previously unsuccessful Whitman, Colonna, or Albee reconstruction.

The statistics on the reconstruction group as a whole show that 58% of the patients obtained satisfactory results (Table 4). In the functional criteria of ability to walk, amount of shortening, limp, range of motion, pain, endurance, and knee function, there was a little difference between this group and the osteosynthesis and osteotomy groups. The mortality rate was 3.5%, which was exceeded only by the osteotomy group. All patients in the reconstruction group had cast immobilization; some in the osteosynthesis and osteotomy groups did not. However, it is interesting to note that these patients had fewer complications and fewer deformities than the patients in either of those groups. In comparison with the nontreatment group, 39.7% more of these patients obtained satisfactory hips.

The reconstruction type of procedure has a definite place in the treatment of nonunion of the neck of the femur. It is probably the one of choice in those cases

4. Albee, F. H.: The Kinesiological Lever in Reconstruction Operations on the Hip, J. Bone & Joint Surg. **22**:406-412, 1940.

5. Batchelor, J. S.: Excision of the Femoral Head and Neck for Ankylosis and Arthritis of the Hip, Post Grad. M. J. **24**:241-248, 1948.

6. Milch, H.: The Pelvic Support Osteotomy, J. Bone & Joint Surg. **23**:581-595, 1941.

in which the head of the femur has undergone degenerative changes. Lateral displacement of the trochanter is apparently better than distal displacement in this procedure. A Batchelor type reconstruction or a Schanz pelvic-support type osteotomy is probably good in those cases in which primary reconstruction has failed.

OSTEOSYNTHESIS

In 22 patients, open reduction, surgical exposure and freshening of the fracture, and bone graft were carried out without internal metallic fixation. The grafts were cortical, either tibia or fibula, extending from the lateral subtrochanteric region up the neck of the femur and across the fracture. This was one of the youngest groups of patients. One patient was only 14 years of age, another was 17, and several were in the third decade. As Henderson [7] and Speed and Smith [8] have pointed out, this procedure is more applicable to younger patients. In our series, 69% of those reported obtained union. Henderson [7b] reviewed 67 open bone graft operations, with the same percentage of union. The incidence of degenerative head changes, 45.5%, was higher in this group than in any of the groups in which the fracture was not exposed and also higher than in the nontreated group. Apparently surgical exposure of the fracture causes more degenerative head changes. We were able to classify 18 cases. In 61.1% satisfactory results were obtained. The percentage of excellent results, 44.4%, was higher in this group than in any other. There was one death, a mortality rate of 4.5%.

Six patients had an open reduction, bone graft, and some type of metallic internal fixation. This was the youngest group of patients. The incidence of union, 80%, was higher, and the incidence of degenerative head changes, 33.3%, was lower than in the previous group. There were no deaths, and 50% of the patients obtained satisfactory hips.

Fifteen patients had a closed reduction and bone graft without internal fixation. Union was obtained in 66.6%. Degenerative head changes were present in 37.5%. Only 40% of the patients in this group had satisfactory hips. Except for the results in the arthrodeses group, these were the poorest results of any of the operative groups. There were two deaths, a mortality of 13.3%.

Two patients had a closed reduction, bone graft, and internal fixation. We were able to classify only one case. This woman obtained a union and had an apparently viable femoral head, but she had severe pain in the hip and was ambulatory only with crutches. The result in this case was classified as poor.

Four patients had an open reduction, bone graft, and high osteotomy. Internal fixation was used in one instance. Three of these patients had adequate follow-up and records. The other patient died of shock, a mortality of 25%. In two of the patients followed union of both fracture and osteotomy was obtained; the other patient did not obtain union of the fracture, but the osteotomy united in good position. Two of the patients had degenerative head changes. In all three cases the results were classified as good.

---

7. (*a*) Henderson, M. S.: Present Day Treatment of Ununited Fractures of the Neck of the Femur, Minnesota Med. **23**:339-343, 1940; (*b*) Ununited Fracture of the Neck of the Femur Treated by the Aid of Bone Graft, J. Bone & Joint Surg. **22**:97-106, 1940.

8. Speed, J. S., and Smith, H.: Trochanteric Osteotomy for Ununited Fractures of the Neck of the Femur, South. M. J. **34**:798-806, 1941.

Six patients had internal fixation only. One died of pneumonia, a mortality of 17%. The remaining five patients obtained union, but three of them had degenerative head changes. In two cases the results were classified as excellent, and in three as fair.

One cartilage cup arthroplasty was performed, as described by Wagner[9] and Moore,[10] in a 61-year-old man. His last examination was only five months following operation. This was too early to judge the result. However, he had a good range of motion, no pain, and was ambulatory with a cane. He obtained a good union of the cup to the upper end of the femoral shaft.

One patient, a 49-year-old woman, had a Brackett[11] type reconstruction and a follow-up of eight years. Solid union of the head to the upper end of the shaft occurred. She walked with a cane, had a slight limp, 50% motion, and 75% normal activity. The result was classified as good.

TABLE 5.—*Osteosynthesis Group*

Total no. of patients		57
Open reduction, bone graft, no internal fixation	22	
Open reduction, bone graft, internal fixation	6	
Closed reduction, bone graft, no internal fixation	15	
Closed reduction, bone graft, internal fixation	2	
Open reduction, bone graft, high osteotomy	4	
Internal fixation	6	
Cartilage cup arthroplasty	1	
Brackett reconstruction	1	
Classification:		
Able to classify	44	
14, or 32%, excellent		
10, or 23%, good		
12, or 27%, fair		
8, or 18%, poor		

Fifty-seven patients had some type of osteosynthesis procedure (Table 5). Of these, 49 had a cortical bone graft from the subtrochanteric region, as described by Albee,[12] Campbell,[13] and Henderson.[14] Albee[12] reported 90% excellent results with his bone peg operation. Gallie and Lewis[15] reported that in six cases out of

9. Wagner, L. C.: A Plastic Operation for Ununited Fracture of the Hip, Am. J. Surg. **6**:801, 1929.

10. Moore, J. R.: Cartilaginous-Cup Arthroplasty in Ununited Fractures of the Neck of the Femur, J. Bone & Joint Surg. **30-A**:313-328, 1948.

11. Brackett, E. G.: Fractured Neck of Femur: Operation of Transplantation of Femoral Head to Trochanter, Boston M. & S. J. **192**:1118-1120, 1925.

12. Albee, F. H.: Treatment of Ununited Fracture of the Neck of the Femur, Surg., Gynec. & Obst. **49**:810-817, 1929.

13. Campbell, W. C.: Ununited Fractures of the Neck of the Femur, South. M. J. **13**:585-588, 1920.

14. (*a*) Henderson, M. S.: Ununited Fractures of the Hip, Surg., Gynec. & Obst. **30**:145-146, 1920; (*b*) Ununited Fractures of the Neck of the Femur, West. J. Surg. **43**:134-142, 1935; (*c*) Extra-Articular Osteosynthesis for Nonunion of the Neck of the Femur, Arch. Surg. **42**:557-565, 1941. (*d*) Henderson.[7a] (*e*) Henderson.[7b]

15. Gallie, W. E., and Lewis, F. I.: Ununited Fracture of the Neck of the Femur in the Aged, J. Bone & Joint Surg. **22**:76-80, 1940.

seven union was obtained with the use of a Smith-Petersen nail and a bone graft. Henderson [16] reported 69% favorable results for open reduction and bone graft and 78.6% favorable results for closed reduction and bone graft. Our results were not as good and were disappointingly low for the closed reduction group. Still, with the open reduction procedure we obtained a higher percentage of excellent results than with any other operation. There is no doubt that the bone graft procedure when it is successful produces the most normal hip of any operation available for nonunion of the neck of the femur. However, it is a rather formidable operation, especially when an autogenous bone graft is used and an open reduction is done. Apparently, it should usually be reserved for the young patient with a good femoral head and neck.

The bone graft and osteotomy group had all good results. A higher percentage obtained union of the fracture than in the simple high osteotomy group, and in the one case in which union of the fracture was not obtained, the result was classified as good because of the stability afforded by the osteotomy. However, the incidence of degenerative head changes was higher with this procedure than with any other. As will be pointed out later, the osteotomies which seem to get the best results are those which convert the fracture to a Pauwel type I rather than the McMurray osteotomy which seeks to gain stability by displacing the shaft medially. Probably it would be better to use the former type of osteotomy with the bone graft procedure rather than the McMurray, as done in this group. King [17] reported using this proposed procedure with good results. This is also essentially what Dickson [18] has described except that he uses cancellous bone at the fracture.

Union was obtained in five cases in which only internal fixation was used. It is difficult to believe the procedure is as good as these results indicate. King [17] reported union in 82% of his cases in which a similar procedure was carried out. In the nonunion of short duration, in good position, and with good structures as seen by x-ray study, it might be acceptable. However, even in these cases, a bone graft procedure is probably preferable.

Ivins and Ghormley [19] reported 80.9% satisfactory results in 71 patients with the Brackett operation, but there was only one such procedure in our series. The patient had a good result. Possibly in some of the younger patients with a viable head but marked neck absorption, the Brackett or Magnuson [20] modification would be of value.

We were unable to evaluate the cartilage cup procedure. The one patient reported here had not been followed long enough to classify. However, Moore [10] has reported

16. Henderson,[7a] Henderson,[14b] Henderson.[14c]

17. King, T.: The Closed Operation for Intracapsular Fracture of the Neck of the Femur, Brit. J. Surg. **26**:721-748, 1938.

18. Dickson, J. A.: The High Geometric Osteotomy, with Rotation and Bone Graft, for Ununited Fractures of the Neck of the Femur: A Preliminary Report, J. Bone & Joint Surg. **29**:1005-1017, 1947; Treatment of Ununited Fractures of Neck of Femur, J. A. M. A. **137**:1199-1206, 1948.

19. Ivins, J. C., and Ghormley, R. K.: Brackett Operation for Ununited Fracture of the Neck of the Femur, Surgery **22**:819-824, 1947.

20. Magnuson, P. B.: The Repair of Ununited Fracture of the Neck of the Femur, J. A. M. A. **98**:1791-1794, 1932; Report of 59 Consecutive Cases of Ununited Fracture of the Neck of the Femur, Surgery **7**:763-772, 1940.

9 patients out of 11 in whom excellent results were obtained with the cartilage cup procedure.[21]

OSTEOTOMIES

It was difficult to group the osteotomies satisfactorily. Those cases in which the osteotomy was done between the trochanters were designated as high osteotomies. Almost all of these were of the McMurray type with the shaft displaced medially beneath the head. When the osteotomy was below the lesser trochanter, they were designated as low osteotomies. These were the Pauwel or modified low Schanz type osteotomies, more recently popularized by Blount.[22] These two major groups were further subdivided into those with and those without internal fixation. There was also one Lorenz bifurcation osteotomy. The follow-up was inadequate, and we were unable to classify it. It was not included in any of the major groups mentioned above.

Thirty-seven patients had high osteotomies without internal fixation. One had a manual osteoclasis and obtained a good result. In one instance the fracture site was exposed and freshened. In all the others, osteotomy was done without exposure of the fracture. All these patients had cast immobilization for an average of one and one-half months. There were no deaths. Eight patients, or 21%, had some type of deformity; six of these were external rotation deformities. In 44%, union of both fracture and osteotomy was obtained. One patient, or 3%, had a nonunion of both fracture and osteotomy. We were able to classify 33 cases. In 51%, results were satisfactory.

Thirty patients had high osteotomies with some type of internal fixation. In one instance the fracture was exposed; in the others it was not. Only four patients had cast immobilization. They had a shorter hospitalization and began weight bearing earlier than those in the previous group. The incidence of deformity was slightly lower in this group also. There were no deaths. However, nine patients had some type of postoperative complication, and in seven of these the complication was related to the internal fixation used. We were able to classify 21 cases. In only 47.66% were the results satisfactory. This was slightly lower than the previous group.

The percentage of satisfactory results from these high osteotomies was disappointingly low. McMurray[23] reported that 15 of 27 patients were able to walk well. Several authors, Hermann,[24] Jahss and Mintz,[25] Leadbetter,[26] and Reich,[27]

21. Twelve cartilage cup arthroplasties have been done at the Campbell Clinic since 1949. In eight of these patients the cup failed to unite with the neck. With this high percentage of failures, we have discontinued the procedure.

22. Blount, W. P.: Blade-Plate Internal Fixation for High Femoral Osteotomies, J. Bone & Joint Surg. **25**:319-339, 1943.

23. McMurray, T. P.: Ununited Fractures of the Neck of the Femur, J. Bone & Joint Surg. **18**:319-327, 1936.

24. Hermann, O. J.: The McMurray Osteotomy for Nonunited Hip Fractures, New England J. Med. **232**:186-189, 1945; Ununited Hip Fractures, ibid. **226**:601-605, 1942.

25. Jahss, S. A., and Mintz, B. J.: Transverse Osteotomy in Ununited Fractures of the Femoral Neck, Bull. Hosp. Joint Dis. **2**:143-153, 1941.

26. Leadbetter, G. W.: Cervical-Axial Osteotomy of the Femur: A Preliminary Report, J. Bone & Joint Surg. **26**:713-720, 1944; The Problem of the Fractured Hip, Nebraska M. J. **30**:309-313, 1945.

27. Reich, R. S.: Ununited Fracture of the Neck of the Femur Treated by High Oblique Osteotomy, J. Bone & Joint Surg. **23**:141-158, 1941.

have reported results varying from 77 to 100% satisfactory with this procedure. If we considered those cases classified as fair as being satisfactory, then our results would be more comparable with those of other authors. However, as stated previously, while the patients in the fair classification group still had some useful hip function, they usually had painful hip motion and limited activities. It is interesting to note, too, that if the cases classified as fair are considered satisfactory, then 40.8% of the nontreatment group were satisfactory rather than the 18.3% we quoted earlier.

Low angulation osteotomy

Only one patient, a 59-year-old woman, had a low osteotomy without internal fixation. She had a follow-up of 13 years and had a fair result. She obtained a union of both osteotomy and fracture, but she had limited painful hip motion with 3 in. (7.6 cm.) of shortening of the limb and limited activities. She had no difficulty with her knee.

Eight patients had low-angulation osteotomies with internal fixation, as described by Blount [22] (Fig.). Only five of them had adequate follow-up for classification. They had relatively short hospitalization; only one patient had cast immobilization. All five patients followed obtained union of both osteotomy and

fracture, and only one patient had any degenerative head changes. Schumm [28] and Gaenslen [29] have pointed out that two of the main objections to this procedure are increased shortening and painful genu valgum deformity. However, the patients in our study had less average shortening than any of the others, and only one had any knee difficulty. There were no deaths or deformities; however, two patients had complications due to the metallic fixation. We were able to classify five cases, and they all had satisfactory results. These were the best results for any group.

As shown by Summers' [30] report, the McMurray type osteotomy is the most popular method of treatment of nonunion of the neck of the femur. But our study does not justify such popularity. Very few of the patients in our study had satisfactory results following a McMurray osteotomy unless they had union of the fracture as well as the osteotomy, and this union of all three fragments was obtained only in less than 50% of the cases. By comparison, however, union of the fracture and osteotomy was obtained in all cases with a modified low Schanz procedure. The latter osteotomy has only one purpose, to change the inclination of the

TABLE 6.—*Osteotomies*

Total no. of patients		77
High osteotomies without internal fixation	37	
High osteotomies with internal fixation	30	
Lorenz osteotomy	1	
Low osteotomy without internal fixation	1	
Low osteotomies with internal fixation	8	
Classification:		
Able to classify	60	
12, or 20.00%, excellent		
20, or 33.33%, good		
12, or 20.00%, fair		
16, or 26.66%, poor		

neck of the femur to a coxa valga position so that the tension of the hip abductors as well as the weight-bearing stress will act as a positive force to continually approximate the fracture surfaces. The McMurray osteotomy does not have this feature. The weight-bearing stress has been shifted medially to the fracture. It no longer acts as a shearing stress across the fracture, that is true, but neither does it act as a positive force for impacting the fracture. Also, the abductors can only rotate the trochanter and, if anything, produce motion at the fracture rather than tend to impact it. An osteotomy which produces a true coxa valga with its positive impacting forces is apparently preferable. Of course, this coxa valga can also be attained by a higher osteotomy, as reported by Schumm,[28] Dickson,[18] and others. In fact, there may be certain advantages in the higher osteotomy site, but, regardless of the site, an osteotomy that produces coxa valga seems preferable.

The statistics on the osteotomy group as a whole are interesting primarily for three things (Table 6): 1. There were no deaths in 77 cases. Apparently an osteotomy is the safest procedure. 2. There were 10% less degenerative head changes in

28. Schumm, H. C.: The Schanz Osteotomy for Fractures of the Neck of the Femur, J. Bone & Joint Surg. **19**:955-963, 1937.

29. Gaenslen, F. J.: The Schanz Subtrochanteric Osteotomy for Irreducible Dislocation of the Hip, J. Bone & Joint Surg. **17**:76-86, 1935.

30. Summers, J. E.: Fractures of the Hip: Methods of Treatment in Use at the Present Time, Internat. Abstr. Surg. **88**:385-387, 1949; in Surg., Gynec. & Obst., May 1949.

this group than in the osteosynthesis group. In most of the osteosyntheses, the fracture was surgically exposed, while in most of the osteotomies the fracture was not exposed. This again demonstrates that surgical exposure of the fracture probably produces more degenerative head changes. 3. Of the 11 complications in this group, 9 were due to the metallic internal fixation used. In 53.3% of these cases, satisfactory results were obtained.

In nearly all criteria the operative group surpassed the nonoperative group. The one notable exception was in the incidence of degenerative head changes, which was essentially the same in the two groups. Of the operative cases classified, 54% had satisfactory results (Table 7). This was an improvement of 35.7% over the nontreatment group.

TABLE 7.—*Group with Operation*

Total no. of patients	197
Classification:	
Able to classify	157
41, or 26%, excellent	
44, or 28%, good	
33, or 21%, fair	
39, or 25%, poor	

CONCLUSIONS

A few conclusions which might be of value may be drawn from this study.[31]

1. A patient with satisfactory hip function usually should not be operated on even though a nonunion may be present. This is especially true in the older age groups.

2. Arthrodesis, at least in this series of cases, has not been a satisfactory procedure for nonunion of the neck of the femur.

3. If the femoral head shows degenerative changes, then probably a reconstructive procedure should be done. (The Albee reconstruction produced the best results.)

4. In the young patient with a good femoral head and neck, a bone graft procedure is the one of choice.

5. Results from the McMurray type osteotomy were not good.

6. The operation of choice in the older patients with viable femoral heads is an angulation osteotomy to produce coxa valga and the use of internal fixation.

DISCUSSION

DR. CARLO S. SCUDERI, Chicago: It is always a pleasure to listen to a paper which comes from the Campbell Clinic because the cases have been recorded well and followed for a long time.

In my experience at the Cook County Hospital in Chicago, results have been very similar to those reported in the statistics and figures presented here. I believe it is commonly agreed that if one is able to obtain a solid bony union between a head, neck, and trochanteric region by the use of bone grafts, it is the best procedure; if it is successful, the operated hip simulates

31. There were no cases in this series in which a prosthesis was used for the femoral head; therefore this type of procedure was not included in the original study. Replacement of the femoral head by a prosthesis may be of value in nonunion of the neck of the femur, especially in older patients with degenerative head changes.

the normal. However, the group of cases in which the bone graft can best be used are a select few, requiring a viable head without any changes in the acetabulum and a patient who can tolerate this type of operative procedure and subsequent period of immobilization.

There are two problems confronting us at present for which I do not feel I have a definite concrete answer in all cases. One problem is that of the aseptic necrosis of the head with a union. In such cases I have tried various procedures in order to revascularize the necrotic head and have had only fair success. This procedure has been advocated by Dr. Dallas Phemister, in whose hands it has been rather successful. In this type of case I have found it best to produce a fusion of the hip as the operation of choice. Fortunately, our results with fusion have been better than the statistics shown here today from the Campbell Clinic. If the procedure is successful, the patient will have a painless, stable hip, and from a clinical and functional standpoint, especially in old people, painless ambulation is possible with some impairment of function.

The other type of problem is nonunion of the neck of the femur with absorption of the neck—in this case the isolated head and the base of the trochanter are in some apposition.

Of the various procedures that I have tried, I feel that the intertrochanteric osteotomy has been most successful in my hands. This may be of the McMurray or the high Schantz type in which the distal fragment is thrust directly below the acetabulum and remaining head and is maintained in this position until a fibrous union occurs. In about one-third of these cases a union develops between the head-trochanteric region and the site of osteotomy. If no union occurs a pseudoarthrosis develops with stability because the shearing force on weight bearing that occurs when a nonunion is present no longer exists. However, one must accept the fact that these patients are never able to get around without the use of a cane or crutch and do have a permanent limp.

I have not had too much experience with substitution of a prosthesis for the head and neck in nonunions, such as the Judie or a similar type of substitution prosthesis, but the patients that I have operated on and followed for a short time and the patients I have seen whom other men have operated on in the Chicago area have left me with the feeling that a successful intertrochanteric osteotomy is as good as, if not better than, some of the substitution operations that I have seen for nonunion of the neck of the femur. Perhaps with more experience I shall be converted to using the substitution method of treatment of nonunion of the neck of the femur with more enthusiasm.

Dr. James J. Callahan, Chicago: The only point I wish to emphasize in discussing this paper is the question of eliminating nonunion of the neck of the femur after a fracture in patients over 70 years of age, especially after a subcapsular fracture, in other words, one involving the head itself. It has been my custom not to treat these patients conservatively because they do not respond, but rather to do an immediate reconstruction, of either the Colonna or the modified Whitman type. When this form of treatment is used, our results are far superior to those obtained from pinning, osteotomy, or any other form of treatment.

Dr. Harold B. Boyd, Memphis: In regard to cartilaginous cup arthroplasty, of which there was only 1 in this series, we have done 12 such operations since these statistics were completed. In eight patients a nonunion between the cartilaginous cup and the neck of the femur developed. We have discontinued this procedure.

In regard to fusion of the hip, this is a good procedure but difficult to perform after nonunion of the neck of the femur in elderly patients. It requires immobilization in a body cast over a long period, which is not well tolerated in old persons.

Replacement procedures of the head and neck of the femur are too new to evaluate. We already know that some types of prostheses now in use have failed in a sufficient number of cases to condemn their further use. Other types may stand the test of time. Certainly, from the data presented in this paper it is clear that at present we do not have an ideal operation for the treatment of nonunion of the neck of the femur in all patients or even in a large percentage of patients. This field is open to the development of new methods, and we should continue to improve present methods and produce better ones.

SACROCOCCYGEAL CHORDOMA

THOMAS J. SNODGRASS, M.D.
JANESVILLE, WIS.
AND
HENRY M. SUCKLE, M.D.
MADISON, WIS.

CHORDOMA is a tumor arising from the remnants of the primitive notochord, slowly progressive, resistant to treatment, with a tendency to invade and destroy bone by direct extension, occasionally metastasizing to distant lymph nodes or viscera. In 1948 Gentil and Coley [1] reported seven cases of sacrococcygeal chordoma treated in the Memorial Hospital from 1930 to 1943 and reviewed 128 cases previously reported in the literature. The following is the report of a case with a review of eight additional cases collected from the literature from 1943 to 1948.

REPORT OF CASE

Mrs. M. Z., aged 70, had been observed in the clinic since 1947 for various unrelated conditions. Her last examination was in July, 1950. A month later she was referred for surgical consultation because of low-back pain of about four weeks' duration. A week prior to this consultation the pain had increased in intensity and was most marked when she was seated. Local application of heat was of no avail. There was no history of trauma, and this was the first complaint of its kind. The pain appeared to originate in the region of the coccyx, and examination disclosed a large firmly fixed mass on the anterior surface of the sacrum and the coccyx. Round, smooth, about the size of a half orange, unattached to the rectal or vaginal wall, the mass was slightly tender. No deformity could be made out externally, but some tenderness could be elicited by pressure over the sacrum and coccyx. Proctoscopic examination showed a normal rectosigmoid, and barium enema revealed a few diverticuli in the transverse colon. Routine laboratory examination revealed moderate anemia and a slightly increased sedimentation rate.

Roentgenological examination showed an indefinitely outlined soft tissue mass overlying the lower portion of the sacrum and the upper portion of the coccyx, mostly on the right side, with an osteolytic and osteogenic bone lesion at the lower portion of this mass. The lateral view showed some osteolytic process at the lower end of the sacrum, probably involving the upper end of the coccyx. Spot films showed a little barium in the rectum, but again demonstrated destruction in the lower end of the sacrum and upper end of the coccyx, trabeculation of the tumor, and a deposit of calcium in the tumor itself (Fig. 1).

Hsieh and Hsieh [2] describe the x-ray findings in chordoma as a "soft tissue mass expanding in type with considerable bone destruction, trabeculated type of shadow with calcium deposits in the tumor itself."

From the Pember Nuzum Clinic (Dr. Snodgrass).

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Dec. 1, 1951.

1. Gentil, F., and Coley, B. L.: Sacrococcygeal Chordoma, Ann. Surg. **127**:432-455 (March) 1948.

2. Hsieh, C. K., and Hsieh, H. H.: Roentgenologic Study of Sacro-Coccygeal Chordoma, Radiology **27**:101-108 (July) 1936.

A tentative diagnosis of chordoma was made on the basis of physical findings and the appearance of the tumor, and biopsy was recommended. This was performed on Aug. 15, 1950. An incision was made over the sacrum and coccyx, the coccyx was exposed, and the exploring needle was inserted into the tumor to the right of the coccyx. A large amount of old blood was aspirated together with some gray flaky material. As the aspiration proceeded the blood appeared of more recent origin. Following removal of the coccyx the dissection then proceeded toward the sacrum, with aspiration directly under the sacrum. The same type of material was removed. A small portion of the partially destroyed sacrum was removed, and at this point a jelly-like tumor mass presented. A portion of this was removed for biopsy, and the wound was closed.

Fig. 1.—Anterior view showing soft tissue tumor with partial destruction of sacrum and coccyx, and calcification in tumor itself.

The pathological examination showed the specimen to consist of a coccyx, several small fragments of bone and fibrous connective tissue, and several irregular fragments of gray, moderately firm semitranslucent tissue measuring from 3 to 12 mm. in diameter. Microscopic sections showed them to be composed of relatively large vacuolated cells separated by varying amounts of homogenous eosin-staining matrix. In most areas the cells were large and oval or polyhedral in outline. Some had light eosin-staining homogenous cytoplasm, but the majority contained one or several roughly-spherical vacuoles (physaliphore cells) of varying sizes. A few of the cells had a signet-ring appearance and in the more cellular areas the cells were compressed. The nuclei varied in size and shape. Some were oval, others somewhat rectangular, and a few were giant and hyperchromatic. No mitotic figures were seen. In some areas the

cells were widely separated by pale-staining mucoid material. A few spicules of cancellous bone were present. The diagnosis was chordoma of the notochord (sacrococcygeal area).

The patient was operated on, Sept. 8, 1950. Under general anesthesia with the patient in semiprone position, the previous incision was excised and extended onto the sacrum. The tendons overlying the posterior aspect of the sacrum were separated from the bone, and the right half of the inferior portion of the sacrum, which was largely destroyed with tumor tissue, was removed with the rongeur. Approximately 2 in. (5.08 cm.) of the fifth sacral nerve roots were sectioned. The dark green-black tumor tissue was evident immediately below this area, and with blunt

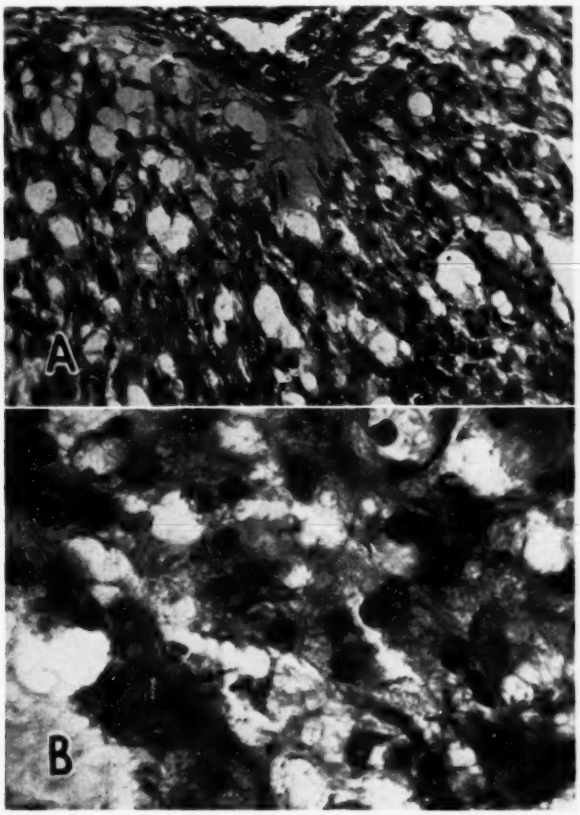


Fig. 2.—Microphotographs of tumor after removal. *A*, × 200; *B*, × 600. (Prepared by Dr. L. V. Ackerman, Washington University.)

finger dissection the lobulated tumor tissue was gradually removed. The tumor extended a distance of approximately 15 cm. superiorly on the anterior aspect of the sacrum and anteriorly into the pelvis for approximately the same distance. The tumor which was attached to the sacrum was first reduced in size by a partial intracapsular removal, thereby allowing space for eventual extracapsular dissection and grossly complete removal. Three large lobulated tumor masses were removed, and at the end of the dissection the posterior wall of the rectum filled the wound to take up the dead space. The anterior sacral wall was curetted to remove the remaining tumor fragments. The bleeding was stopped by the application of hot packs, and electro-

coagulation. A piece of gelfoam was placed over the wall of the rectum, and the wound was sutured with interrupted cotton sutures in layers. The patient was given two units of blood during the procedure, and her condition remained very good during the entire operation.

Pathological examination of the gross specimen showed 250 gm. of soft hemorrhagic yellowish gray semitranslucent tissue in one large and numerous small irregularly shaped pieces. One surface of the largest piece, which measured 8 × 6.5 × 3.5 cm., was lobulated and covered by thin fibrous connective tissue capsule, while the other surface was ragged. Sections showed semitranslucent soft gray tissue with scattered small irregular areas of opaque firmer yellow tissue. Small areas of calcification and large and small areas of hemorrhage were present throughout. The smaller fragments were yellowish gray with considerable hemorrhage. There was no normal tissue present.

Microscopic sections (Fig. 2) resembled those of the biopsy specimen, with large vacuolated polyhedral cells supported by varying amounts of mucoid matrix. In addition some sections showed giant cells with many nuclei, other cells with large bizarre nuclei, and a moderate number of cells in mitosis.

With special stains much of the matrix stained positively for mucin, and individual tumor cells were found to contain a small amount of glycogen.

It was felt, because of the marked variations in the cells, the bizarre nuclear pattern, and the relatively numerous mitotic figures, that the lesion represented a fairly malignant variant of this neoplasm. The diagnosis was chordoma of notochord (sacrococcygeal area).

This patient has been observed at regular intervals. She has been entirely comfortable, with no disturbance of bladder or bowel function and with only a slight tenderness when she sits on the side of the sacrum on which operation was performed. On examination by both of us in October, 1951, a very small smooth rounded mass 0.5 × 2 cm. could be felt on the remaining portion of the right side of the sacrum. This may be a recurrence. X-ray examination showed no additional bone involvement at this stage.

COMMENT

Presacral tumors are rare. According to Dockerty,[3] about 50 cases have been seen in the Mayo Clinic, or 1 in 30,000 admissions. In differential diagnosis one must think of (1) infectious processes, such as tuberculosis; (2) bone tumors, such as a giant cell tumor or chondrosarcoma; (3) neurogenic tumors, such as neurofibroma and ganglioneuroma; (4) tumors of surrounding organs, such as the pelvis or rectum, and (5) congenital anomalies, such as anterior meningocele and teratoma.

Virchow[4] first described small tumor-like masses at the spheno-occipital synchondrosis in 1856. It was his belief that this tumor was essentially cartilaginous in nature, and he called it ecchondrosis (from cartilage) physaliphora (vacuole-containing cells). Two years later Müller[5] suggested the relationship between this growth and the chorda dorsalis and introduced the term "chordoma." In 1894, Ribbert[6] established the true nature of this neoplasm and reported five cases of his own. Ribbert[6] is credited with demonstrating that the derivation of the chordoma is from notochordal remnants. The first case of sacrococcygeal chordoma was

3. DeVoe, R. W.; Lovelady, S. B.; Dockerty, M. B., and Gray, H. K.: Pregnancy Complicated by Presacral Neurofibroma, One of the So-Called Middeldorpf Tumors, Proc. Staff Meet., Mayo Clin. **23**:239-244 (May 12) 1948.

4. Virchow, R. L. K.: Entwicklung des Schädelgrundes: Die krankhaften Geschwültse, 1856; cited by Gentil and Coley.[1]

5. Müller, H.: Über das Vorkommen von Resten der Chorda dorsalis bei Menschen nach der Geburt und über ihr Verhältniss zu den Gallertgeschwülsten am Clivus, Ztschr. rat. Med. **2**:202-229, 1858.

6. Ribbert: Über die Ecchondrosis physalifora sphenooccipitalis, Centralbl. allg. Path. **5**:457-461, 1894.

described in 1900 by Henning.[7] These tumors may occur at any age. They are usually encountered at about the fifth decade of life.

In the 128 cases analyzed by Gentil and Coley,[1] the youngest patient was 3 months old and the oldest 78 years; the average age was 46. In the Memorial Hospital series of seven cases, the youngest patient was 50 years, and the oldest, 70. Of all the chordomas of all types in the 161 cases encountered up to 1935, including the Memorial Hospital series, 60% were coccygeal type, 30% occurred in the spheno-occipital synchondrosis, and 10% were distributed along the spine in the cervical, lumbar, and thoracic regions. Of the sacrococcygeal type there were seven on record in the Memorial Hospital over a period of 13 years, during which time there were 31,099 first admissions.

As to the occurrence of these tumors at either end of the vertebral column, it is noted that the development of the vertebral column is completed first at the thoracic level and last at the extreme ends, with the result that a greater percentage of developmental anomalies occurs at these extremes. Other congenital anomalies such as spina-bifida meningocele occur more frequently at the extreme upper and lower levels of the spinal column. While from the literature it appears that 30% of these tumors occur at the spheno-occipital junction, from the experience of one of us (H. M. S.) this percentage would appear high. The more frequent appearance in the sacrococcygeal region is probably due to the fact that there is a greater amount of primitive notochordal tissue remaining in this area.

Radiation has little effect on this slow-growing tumor. It becomes invasive and destructive only when it meets with some resistance in the path of its growth, as in the sacrum. Widespread metastases do occur, though rarely, to the lungs, liver, and peripheral lymph nodes. Pulmonary metastases were reported in approximately 5% of the cases in the literature. The only effective treatment, then, is surgical removal, which is somewhat difficult because of the location of the tumor. In the patients that survive it is frequently necessary to reoperate several times for local recurrences. Several authors report the entire operation by electrocoagulation. Preoperative radiation has been tried without benefit. Only in inoperable cases has radiation been used extensively. Gentil and Coley [1] suggest the possibility of doing a preliminary colostomy and ureteroenterostomy, followed by complete removal of all the tissues involved. However, this has not been carried out, as it appears too radical for a tumor of this degree of malignancy.

One of the cases in which treatment was most successful was that reported by Brindley.[8] He used a cautery excision combined with roentgen therapy. He cauterized the bone thoroughly so that it was necessary on two subsequent occasions to perform sequestrectomies with curetting and packing of the resulting sinuses. His patient was operated on in 1941 and was last seen in 1944. There was no evidence of recurrence at that time.[9]

We have reason to feel that the disease in our patient was of fairly short duration, inasmuch as she had frequent examinations, and symptoms were absent up to the time of the hemorrhage into the capsule. Review of cases reported in the literature shows that in Anguli's patient [10] the chordoma was associated with severe constipa-

7. Henning, L.: Über congenitale echte Sakraltumoren, Beitr. path. Anat. **28**:593-619, 1900.

8. Brindley, G. V.: Sacral and Presacral Tumors, Ann. Surg. **121**:721-736 (May) 1945.

9. In the discussion it developed that this patient is still alive.

10. Anguli, V. C.: Case of Sacrococcygeal Chordoma, Indian J. Surg. **10**:208-210 (June) 1948.

tion and an area of anesthesia, saddle-shaped, in the perineum. Brindley's patient [8] had a growth beneath the skin over the sacrum for about five years following an injury. Roux's patient [11] had constipation, difficulty in defecation, and bladder disturbances, as well as loss in weight of about 12 lb. (5.4 kg.), in the previous year. Marottoli's patient,[12] aside from having severe pain compelling her to stay in bed for two months, had an indication of nerve involvement on the right side. Wells's patient [13] had difficulty with bowel movements. Carranza's patient [14] found walking impossible because of pain and was compelled to stay in bed. He had diminished reflexes in the lower extremities and hyperesthesia in the distribution of the left sciatic nerve, as well as a positive Laseague's sign on both sides. Pérez Fontana's patient [15] had urinary retention. Guri's patient [16] had radiating pain along the outer aspect of the leg and foot, with numbness in the outer aspect of the thigh. In all these cases the disease was of long duration. In a number of cases reported by Gentil and Coley,[1] chordotomy was necessary for intractable pain, and it was necessary also in Guri's case.[16]

Cases Collected from the Literature Since the Report of Gentil and Coley [1]

Author	Year	Sex	Age	History of Trauma	Histologic Diagnosis, Section or Aspiration	Duration Symptoms	Treatment Radiological or Surgical	Recurrence	Metastasis	Survival Period	End Result
Angulli	1943	M	32	No	Aspiration	2 yr.	Surgical	.....	....	16 hr.	....
Brindley	1945	F	44	Yes	Section	5 yr.	Radiological and surgical	No	No	3 yr.	?
Roux	1945	M	66	Yes	Section	6 yr.	Surgical	?	No	?	?
Marottoli	1946	F	38	Yes	Section	3 yr.	Radiological and surgical	?	?	?	?
Wells	1947	M	37	Yes	Section	12 yr.	Surgical	Expected	No	....	....
Carranza	1947	M	26	No	Section	2 yr.	Surgical	No	....	8 mo.	?
Pérez	1947	M	14	Yes	Section	15 days	Surgical	Yes	Yes	?	Dead
Guri	1948	M	54	Yes	Aspiration	2 yr.	Radiological	.....	....	2 yr.	Dead

Note: Since this report, six additional cases have been reported by Collin S. MacCarty, John M. Waugh, Charles W. Mayo, and Mark B. Coventry (The Surgical Treatment of Presacral Tumors a Combined Problem, Proc. Staff Meet., Mayo Clin. **27**:73-84 [Feb. 13] 1952).

Of the patients treated in Memorial Hospital in New York and reported on by Gentil and Coley,[1] one still had the disease at the end of five years; another was dead of the disease at the end of 11 months; the third still had the disease at five years and 4 months; the fourth and fifth still had the disease at four years; the sixth was dead of the disease after one year and 2 months; and the seventh died of leukemia in one year and 4 months, with no evidence of recurrence of the disease.

11. Roux, J. R.: La chordome sacro-coccygien, Union méd. Canada **74**:1707-1710 (Dec.) 1945.

12. Marottoli, O. R., and Cid, J. M.: Sacrococcygeal Chordoma, with Report of a Case, Bol. Soc. cir. Rosario **12**:211-220 (Aug.-Nov.) 1945; Ann. cir. **11**:50-60 (March-June) 1946.

13. Wells, A. H.; Swenson, A. O., and Joffe, H. H.: Sacrococcygeal Chordoma: Presentation of Case, Minnesota Med. **30**:863-866 (Aug.) 1947.

14. Carranza, F. F.: Sacrococcygeal Chordoma: Surgical Therapy of Case, Bol. y trab., Acad. agrent. de cir. **31**:183-194 (May 7) 1947.

15. Pérez Fontana, V., and Cabrera Roca, M. T.: Cordoma en la región sacra-coccígea en uno niño 14 años, Cong. interam. cir. (1946) **3**:145-150, 1947.

16. Guri, J.: Tumors of the Vertebral Column, Surg., Gynec. & Obst. **87**:583-598 (Nov.) 1948.

SUMMARY

A discussion of sacrococcygeal chordoma has been presented, with report of a case and review of eight cases for the literature since the report of Gentil and Coley.[1] In the case reported here diagnosis was inferred by roentgen examination of the sacrum and the coccyx, and by rectal examination. The appearance was characteristic of chordoma, showing an expanding soft tissue tumor with bone destruction, trabeculation, and calcification. Final diagnosis was made by microscopic study of biopsy material. The treatment was surgical excision. X-ray treatment was not used in this case.

DISCUSSION

DR. HENDRIK J. SVIEN, Rochester, Minn.: I think that this paper by Dr. Snodgrass and Dr. Suckle is a very important one, because their method of handling their case of sacral chordoma represents an advance in the treatment of this condition. These tumors are of a soft consistency and are often lobulated, but they are encapsulated. As they grow, they frequently erode through the anterior or posterior wall of the sacrum or through both walls, and encroach on the sacral nerves, sometimes enveloping them but more often merely displacing them.

Accumulated experience in treating these tumors has elucidated the following points: 1. Subtotal removal is followed by recurrence. 2. Distant metastasis occurs in about 10% of cases. 3. Radiation therapy is of little value in controlling or eliminating this type of tumor.

From the foregoing considerations, it is evident that the ideal treatment would consist in total removal. In order to effect total extirpation, the method employed by Drs. Snodgrass and Suckle must be employed—namely, removal of as much of the sacrum as is involved and sparing of the second and third sacral nerves on one side, at least, so that rectal and vesical function is not disturbed. It has been the experience of my colleagues and me that, at least grossly, the tumor can be totally extirpated in a good percentage of these cases with preservation of rectal and vesical control. We now have five or six cases handled in the same way as the case reported here, in which we believe a total removal has been accomplished, and in which rectal and vesical control has been preserved. We have worked as a team, general surgeon and neurosurgeon, as the authors have done, to accomplish this end. The colon must be freed from the tumor, the involved sacrum removed, and the nerves to the rectal and vesical sphincters preserved.

There is another point which Dr. Snodgrass brought out which, I think, is important. He preceded his surgical intervention with a biopsy. This should be done whenever possible. Just recently, I saw a patient who presented signs and symptoms of this type of tumor. She was being prepared for operation when, on a second visit, I noticed a suggestion of a mass in her forehead. A roentgenogram of the skull revealed a punched-out area. Biopsy of this cranial lesion proved this tumor to be a metastatic lesion from the thyroid.

DR. H. H. BRINDLEY, Temple, Texas: I should like to make a further follow-up report on my father's case which was mentioned in this review of the literature.

I saw his patient about six months ago. At this time, a little over ten years after surgery, her general health was good and there was no evidence either of local recurrence or of metastasis.

One other thing, about two years ago, at the Campbell Clinic we had a case which looked very similar in x-rays to the one shown here by Dr. Snodgrass. Biopsy of this lesion revealed it to be a giant cell tumor of the sacrum.

DR. THOMAS J. SNODGRASS, Janesville, Wis.: I want to thank Dr. Svien and Dr. Brindley for their discussion of this case. Dr. Svien worked late last night looking over this paper so he could present this very fine discussion.

Dr. Brindley's father has the rare distinction of having found the way to cure one of these patients. Dr. Sanders just told me that he had never seen a tumor of this type. It is not strange, for the incidence in the Memorial Hospital was 7 in over 30,000 first admissions. Chordoma is a rare but very interesting type of tumor.

EXTRA-ADRENAL ABDOMINAL PHEOCHROMOCYTOMA

JOHN HOMER WOOLSEY, M.D.
AND
WOODRING PEARSON, M.D.
WOODLAND, CALIF.

PHEOCHROMOCYTOMA, an epinephrine- and arterenol-producing tumor, has now become recognizable and is safely removable by surgery. Graham [1] estimates that in the United States more than 800 patients die annually of this disease, and many of these are avoidable deaths. More of these lesions are being reported as removed surgically before irreversible circulatory changes have occurred. This report is based on the experience of a successfully operated extra-adrenal tumor located in the left retroperitoneal para-aortic region.

NATURE OF THE TUMOR

This tumor has at times been called a chromaffinoma, since it arises from the cells in the chromaffin system but is known better by the term pheochromocytoma —pheo, of Greek derivation, meaning dark; chromo, from the Greek, significant of color staining dark with chrome salts; and cytoma, from the Greek, denoting cell and cell tumor. This tumor is found throughout the chromaffin system distribution; in the medulla of the adrenal glands; in the para-aortic ganglia intimately associated with the sympathetic chain in the retroperitoneal spaces, one of these being located just above the bifurcation of the aorta and known as the organ of Zuckerkandl; in the retropleural region, and even in the brain. The carotid glands at the bifurcation of the carotids are a part of the chromaffin system, but to date no pheochromocytoma has been reported there. In the last reported analysis [1] of 207 pheochromocytomas, the number of tumors located in the right adrenal gland was 92, in the left 70, in the right lumbar paravertebral space 7, in the left 5, in front of the great vessels of the abdomen 4, in the organ of Zuckerkandl 4, in the left thoracic paravertebral space 2, and in the celiac ganglion 1. Smithwick [2] reports one intracranial tumor.

The age distribution was reported by Snyder and Vick [3] in 1947 and later by Graham [1] in 1950 as two in the first decade, 23 in the second, 47 in the third, 47 in

From the Woodland Clinic.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Dec. 1, 1951.

1. Graham, J. B.: Pheochromocytoma and Hypertension: An Analysis of 207 Cases, Internat. Abstr. Surg., in Surg. Gynec. & Obst. **92**:105-121, 1951.

2. Smithwick, R. H.; Greer, W. E. R.; Robertson, C. W., and Wilkins, R. W.: Pheochromocytoma: A Discussion of Symptoms, Signs and Procedure of Diagnostic Value, New England J. Med. **242**:252-257, 1950.

3. Snyder, C. H., and Vick, E. H.: Hypertension in Children Caused by Pheochromocytoma, Am. J. Dis. Child. **73**:581-601, 1947.

the fourth, 54 in the fifth, 30 in the sixth, 5 in the seventh, and 1 in the eighth. The youngest patient was 5 months old and the oldest 72 years.

This tumor is benign in its growth behavior as a rule, but metastases have been reported. Pheochromocytomas occur frequently in two locations, being in 20% bilateral. When bilateral they occur oftenest in each adrenal gland and then most frequently in an adrenal gland and an extra-adrenal location. A complete exploration of the chromaffin system should therefore always be done at the time of surgery in suspected instances of this tumor.

SYMPTOMATOLOGY AND DIAGNOSTIC AIDS

The main symptoms of extra-adrenal pheochromocytoma are as follows:

1. Hypertension, usually paroxysmal, may be persistent, and yet if these tumors are discovered early no doubt will not always be found present; among the symptoms of hypertension, increased nervousness and irritability, tachycardia and palpitation, early fatigue, and headache are the commonest.

2. Excessive sweating.

3. Peripheral vasomotor phenomenon of a cool skin and pallor, numbness and tingling of extremities, and often recognizable constriction of the retinal arteries.

4. Fever, an internal reaction due to peripheral vasoconstriction interfering with heat elimination.

5. Normal cold pressor test.

6. Increased blood sugar.

7. Increased metabolic rate.

In this disease the diagnostic aids are as follows:

1. X-ray studies in the form of pyelograms for adrenal enlargement pressure deformities, chest films for para-aortic tumors, and intestinal barium studies for more exact tumor location.

2. Massage of the tumor, with a possible coincidental rise in the blood pressure.

3. Positive reaction in blood pressure with histamine, methacholine chloride (mecholyl® chloride), and/or tetraethylammonium (etamon®) bromide or chloride.

4. Adrenolytic or blocking drugs such as piperoxan hydrochloride, N,N-dibenzyl-betachloroethylamine hydrochloride (dibenamine®), and 2-(N′*p*-tolyl-N′-*m*-hydroxyphenyl-aminomethyl) imidazoline (regitine [C 7337]).

The use of adrenergic drugs [4] for stimulation or blocking is fraught with some danger and a thorough understanding before employing them is necessary. They are still in the period of investigation.

4. (*a*) Evans, J. A.; Rubitsky, H. J.; Bartels, C. C., and Bartels, E. C.: Re-Evaluation of the Reliability of Pharmacologic and Cold Pressor Studies in Hypertension and Pheochromocytoma, Am. J. Med. **11**:448-460, 1951. (*b*) Shapiro, A. P.; Baker, H. M.; Hoffman, M. S., and Ferris, E. B.: Pharmacologic and Physiologic Studies of a Case of Pheochromocytoma, Am. J. Med. **10**:115-130, 1951. (*c*) Richards, V., and Hatch, F. N.: Surgical Experiences with Pheochromocytoma, Ann. Surg. **134**:40-54, 1951. (*d*) Kositchek, R. J., and Rabwin, M. H.: Pheochromocytoma Successfully Removed with the Aid of Piperoxan (Benodaine) Hydrochloride, J. A. M. A. **144**:826-830, 1950. (*e*) Conley, J. C., and Junkerman, C. L.: Lack of Specificity of Piperoxane Hydrochloride Test for Adrenal Medullary Tumors, J. A. M. A. **147**:92-123, 1951. (*f*) Grimson, K. S.; Emlet, J. R., and Hamblen, E. C. Diagnosis and Management of Tumors of the Adrenal Gland, Ann. Surg. **134**:451-463, 1951. (*g*) Graham.[1]

The clinical picture as a whole is, however, of the greatest importance. It is only with diligence in the history-taking and careful, thorough, and repeated study that the diagnosis can often be established. It is in persons with hypertension more frequently paroxysmal, hyperthyroidism, or suspected tumors of the pancreas, or in that unfortunate group of persons frequently labeled psychoneurotics, that we must be alert for the presence of pheochromocytoma. There will be, in addition, neck tumors, chest tumors, and retroperitoneal tumors; in fact, any tumors in the region of the chromaffin system distribution area that do not necessarily present the typical clinical picture but carry potential future danger must be explored. With rare exceptions these tumors are 5 cm. or less in diameter. It is important therefore that the surgeon keep this tumor in mind in his differential diagnosis of a neck, chest, or abdominal tumor, and that at the operating table he understand how to carry out the dissection in order to avoid preferably or to handle properly the suddenly induced hypertension and dramatic sudden drop with which shock and death can promptly occur. It is in the early stage of pheochromocytoma before such diffuse hyperplastic sclerosis in small arteries and arterioles has occurred that successful surgery can best be done. The following experience illustrates aspects of the problem.

REPORT OF A CASE

F. V., a 23-year-old white married poultryman, was seen April 6, 1951. He complained of a recurrent dull aching pain in the left lower quadrant of four years' duration. This pain radiated into the left lumbar region and to the left testis; it was increased with exercise and with recumbency and was relieved by bending forward at the hips, at times by voiding, and at times by bowel movement. He had enjoyed a normal boyhood, suffered a head injury with unconsciousness for 12 hours in 1945 but without any sequelae, served in the United States Army in 1946, and had a lower extremity minor injury in 1947, approximately five months before his present complaint when his first available recorded blood pressure of 120/80 was made. He had continued regularly at work, but with the increasing frequency and persistence of his pain, consultation was held.

Examination showed a well-developed and well-nourished, 5 ft. 9 in. (175.2 cm.), 130¾ lb. (59 kg.) healthy man. The skin was normal. Ocular fundi were normal, the tonsils small, and the lungs clear. The heart was normal, with a Grade II blowing aortic systolic murmur. The blood pressure was 140/70 and the pulse rate 42. The abdomen was flat and muscular, with no spasm or tenderness. A palpable 5 cm. fixed, firm, nontender, deeply placed left abdominal tumor was found just above and lateral to the umbilicus. The liver, spleen, and kidneys were not palpable. Findings on rectal examination were normal. The prostate was of medium size. No hernia was present. The spine was normal. All reflexes were present and normal. Sigmoidoscopic examination revealed no abnormalities.

X-Ray Report (by John D. Lawson, M.D.).—On Sept. 25, 1950, roentgen examination of the colon, pelvis, and genitourinary tract was made. A barium enema was transmitted normally and rapidly throughout the length of the colon and into the terminal ileum. The two structures appeared to be normal.

X-rays of the urinary tract showed a normal kidney outline and psoas shadows. There were no opacities suggesting calculi. The lumbar spine also appeared to be entirely within normal limits, there being no evidence of disease, injury, or abnormality. The bony pelvis showed normal conformity throughout.

Excretory Urography (April 10, 1951) (by Earl H. Gray, M.D.).—A preliminary x-ray showed no evident abnormality in the size or position or contour of the soft-tissue outlines of either kidney, and no opacities were seen within their shadows or along the expected course of either ureter. Both psoas muscle shadows were present and not obliterated. The left kidney shadow was at a little higher level than the right and did not appear displaced by a retroperitoneal mass. Dye injected intravenously collected promptly on both sides, and in a series

of x-rays the minor calyces, pelves, and upper ureters were outlined and did not appear abnormal. When the patient stood, each kidney moved down over a centimeter and no blockage to drainage occurred. No significant splenic shadow was evident, and no opacities were seen in the expected region of the pancreas.

Conclusions: No significant disease was demonstrated in the upper urinary tract; the left kidney shadow was perhaps a little larger than the right but no diagnostic distortion of the calyces or pelves was evident.

Gastrointestinal Series (April 13, 1951) (by Earl H. Gray, M.D.).—Fluoroscopically the antra appeared aerated and nothing important was seen in the chest or in an anterior x-ray of it. A barium meal did not outline abnormalities of the esophagus, stomach, cap, or duodenum. Positional studies were made without demonstration of displacement of the stomach, cap, or duodenum by an extrinsic mass, and x-rays were made at fifteen minute and at two and one-half hour intervals without demonstration of abnormality in the appearance of the small bowel. At two and one-half hours the stomach was empty and the lower small bowel did not appear unusual and barium had reached the hepatic flexure.

Conclusions: No intrinsic disease was demonstrated in the upper gastrointestinal tract. No displacement of the upper gastrointestinal tract by an intrinsic mass was demonstrated.

Labatory Data.—Blood studies, May 8, 1951, showed a color index of 0.88. The red cell count was 5,250,000, hemoglobin 4.3 gm. (92%), and white cell count 13,700, with 9% lymphocytes, 71% neutrophiles, 9% stab forms, 11% juveniles, and 0% eosinophiles. Urinalysis showed a specific gravity of 1.028; a Ph of 6; negative reactions for albumin and sugar; 0 to 1 pus cells; 0 to 2 erythrocytes. There were no bacteria and no casts.

Operation (May 8, 1951).—A preoperative diagnosis of left upper quadrant tumor, probably pancreatic in origin, was made. Anesthesia was induced by thiopental sodium (pentothal® sodium) injected intravenously and maintained with nitrous oxide and oxygen, meperidine hydrochloride (demerol® hydrochloride), and curare. Dextrose 5% in isotonic saline solution was administered intravenously.

A left midtransverse abdominal incision was made. Exploration showed a retroperitoneal para-aortic 5 cm. slightly bosselated, firm, evenly consistent tumor just below the pancreas and at the base of the mesocolon. There was no other mass, and a complete and thorough abdominal exploration showed entirely normal findings. Later after recognition of the type of tumor, careful palpation of the adrenal regions showed entirely normal findings. Dissection to remove the tumor demonstrated that its arterial blood supply was primarily a 0.5 cm. long artery stemming directly from the aorta and the several veins located at the posterior lower inner aspect. The peritoneal covering separated easily, and the entire tumor was eventually enucleated cleanly. The superior and lateral aspects of the tumor were first separated by scalpel dissection under direct vision. At this stage sponge pressure and rolling of the tumor to display the arterial supply were made, and coincidentally the blood pressure began to rise. Because of the continuous rise of blood pressure and the vascularity of the tumor, the probability of an epinephrine-producing tumor was suspected and immediately 1,000 cc. of isotonic sodium chloride solution with 5 cc. epinephrine was connected into the intravenous administration ready for use. The dissection was continued and the arterial supply clamped and severed. The blood pressure, with the finger pressure and massage used in rotating the tumor for dissection removal, continued to rise to 300 mm. Hg when the venous channels were clamped. Coincidentally, the blood pressure dropped abruptly to 90 systolic, and definite sweating occurred. At this time use of epinephrine solution was started and the blood pressure taken every half minute at first and later at wider intervals. The epinephrine solution was, as indicated by blood pressure readings, given until one and a half hours post removal of the tumor when the blood pressure became stabilized at 110/60. After the venous channels of the tumor were clamped and the blood pressure adjusted with the epinephrine solution, the surgery proceeded without event to completion. The patient left the operating table in excellent condition in all particulars but was constantly attended by a physician for the next two hours.

The patient's postoperative course was uneventful. He was dismissed from the hospital on the 10th postoperative day. Six weeks postoperatively he returned to his regular work as a poultryman and has continued to enjoy the best of health and freedom from the original complaint of left abdominal pain. The blood pressure continued at 118/70 and the pulse rate at 66.

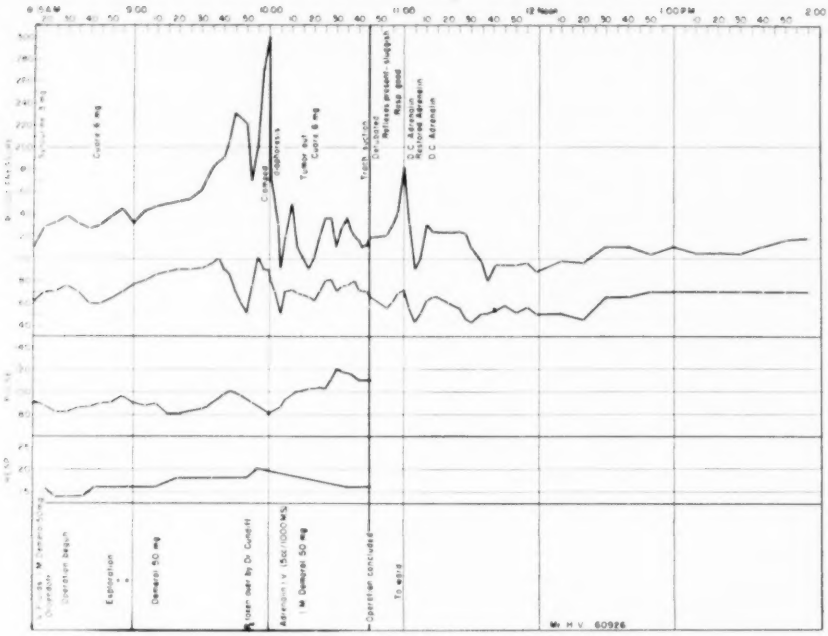


Fig. 1.—Blood pressure during and after surgery.

Fig. 2.—Retroperitoneal tumor (pheochromocytoma) hemisectioned, showing some vascularity.

Pathology Report (May 8, 1951) (by David A. Wood, M.D.).—Gross Specimen: An oval encapsulated tumor was partially hemisectioned prior to fixation and weighed 51 gm. It had over-all measurements of 5.5 by 5.0 by 4.6 cm. Its previously cut surface was slightly opaque and showed much brownish discoloration. A subsequent transverse section, however, showed mottled, rather sharply circumscribed, prominent, yellowish-orange areas measuring up to 0.8 cm. in width which were frequently coalescent. Also present were some other firm purplish areas measuring up to 1.2 cm. in width.

Histological Examination: Sections showed a tumor with a delicate honeycombed fibrous stroma supporting thin-walled blood vessels. Between the strands of stroma were solid cords and masses of tumor cells. The latter were remarkably uniform in size and shape and staining characteristics. They were rather large, polygonal, and closely grouped. Cytoplasm was abundant and finely granular. Nuclei were small and spheroidal and showed finely reticulated chromatin. The pathological diagnosis was retroperitoneal pheochromocytoma on the left side, site of origin unknown.

COMMENT

This experience has demonstrated that in the early stage a pheochromocytoma may not present any of the characteristic symptoms. Preoperative massage of this tumor was not done, but this maneuver has not always clinically yielded a positive blood-pressure-raising phenomenon, and yet at the time of surgery this was without doubt the primary disturbing factor. The clamping off of the arterial supply had no effect, while with the clamping off of the venous channels an immediate and dangerous drop of the blood pressure dramatically occurred. Being prepared with blood pressure stimulation by the epinephrine solution for instant use was undoubtedly lifesaving in this instance. Such prompt and continuous blood-pressure support has been reported and advised [5] using epinephrine, 5 to 8 cc. in 1,000 cc. of isotonic sodium chloride solution and later epinephrine in oil intramuscularly. Bartels and Cattell [6] have expressed the opinion that the use of epinephrine to combat the drop in blood pressure is not always indicated, believing that the reaction may be due to the previous increase of blood pressure with subsequent acute heart failure. They have advised the preoperative use of dibenamine® to neutralize any excess of epinephrine, and then when collapse occurs they place the patient in the Trendelenburg position.

Grimson, Emlet, and Hamblen [4f] have studied and used regitine [C 7337] for its adrenolytic action at surgery as well as for tests in diagnosis and have found it most effective. It appears that regitine [C 7337] is a drug of shorter duration effect than dibenamine® or piperoxan hydrochloride and therefore safer. Litman and State [7] emphasize in the use of an andrenolytic drug the danger of making the patient refractory to epinephrine stimulation. Our experience supports that of many such as Decker, McDowell, and Trimble,[8] that epinephrine in isotonic sodium

5. Graham.[1] Smithwick.[3] Richards.[4c]

6. Bartels, E. C., and Cattell, R. B.: Pheochromocytoma, Its Diagnosis and Treatment, Ann. Surg. **131**:903-916, 1950.

7. Litman, N. N., and State, D.: Pheochromocytoma: Use of N,N-Dibenzyl-β-Chloroethylamine (Dibenamine®) and Piperidino-Methyl-Benzodioxane (Benzodioxane®) in Surgical Therapy, Pediatrics **4**:735-743, 1949.

8. Decker, H. C.; McDowell, F. W., and Trimble, I. R.: Pheochromocytoma: Case Report with Discussion of Differential Diagnosis and Surgical Treatment, J. A. M. A. **147**:642-643, 1951.

9. Grimson, K. S.; Longino, F. H.; Kernodle, C. E., and O'Rear, H. B.: Treatment of a Patient with a Pheochromocytoma, J. A. M. A. **140**:1273-1274, 1949.

chloride solution is a reliable supporting solution for the dangerous blood pressure drop. However, with the knowledge of today the use of regitine [C 7337] preoperatively and during surgery would appear the best plan.

In order to preserve the ability of the tumor tissue to be stained with chrome salts, for which it has an affinity by its origin, it should be placed in Zenker's fluids which contains the dichromate salt, not in the usual 5 to 10% solution of formaldehyde.

CONCLUSIONS

Pheochromocytomas are amenable to cure, have to be considered in the differential diagnosis of any tumor occurring in the chromaffin system distribution area, and are desirably removed before irreversible arterial damage in the kidney and peripheral vessels has occurred. The clamping off of the venous channels early in the surgical dissection to prevent the massaging out of epinephrine into the blood stream before blood pressure change occurs is indicated. The preparation for prompt administration of epinephrine solution for blood pressure stimulation may be lifesaving. Consideration of adrenolytic blocking drugs, and as piperoxan hydrochloride or regitine [C 7337], for use before and during surgery must be given.

DISCUSSION

DR. HENRY H. SEARLS, San Francisco: I have seen a number of cases like this at the University Hospital. I am sorry I couldn't find Dr. Earl Miller in the audience because recently we have been injecting oxygen into the space immediately behind the anus and lighting up the whole retroperitoneal and the whole perianal space for x-ray examination. In the last case we discovered an intrathoracic goiter!

There is one other point and that is that no one should perform an operation like this without having expert medical advice right at hand for treatment of any rise or fall in blood pressure.

HINDQUARTER AMPUTATION

Report of Ten Cases

W. E. LEIGHTON, M.D.
ST. LOUIS

I REPORTED 3 interpelvic abdominal amputations in 1942 and collected and tabulated all reported cases, which totaled 108. Only six surgeons in the United States had performed this colossal mutilation. Since that date there have been many reports of this major amputation, and now, 9 years later, 187 cases have been added; my 7 cases make the total 194, nearly double that of the previous 50 years.

During the past decade many American surgeons have reported a series of cases, but Coley and Higginbotham head the list with 14 cases. To Gordon Taylor, an English surgeon, belongs the honor of having performed 33 hindquarter amputations.

The operation in most cases is employed for removal of tumors of the pelvic bone, either primary or metastatic. As in most cases of cancer, only a radical procedure offers a chance of cure, and delay in diagnosis and partial excision remove the possibility of cure.

Pringle in 1915 was the fifth surgeon to report a successful operation. In his report of five operations, he made a most significant statement:

> There has scarcely been a single operation of any magnitude that has not in the early stages of its development been looked at askance, and the interpelvic abdominal amputation must always remain one of the severest in surgery. But if the real nature of these cases be recognized at an early stage and the operation can be carried through before the patients have commenced to run down in consequence of the disease, the mortality following it will, I believe, be so far diminished that justification of the operation will in the future be generally admitted.
>
> Today in spite of the many reports of successful operation and many reports of five years or more cure, we find many skeptics. In one of our recent books on operative surgery, we find this paragraph: "The hindquarter amputation will not be described as it is rarely done and it is questionable if it is ever justified."

Hesitance on the part of the physician to recommend such a mutilating operation—it has a high mortality and its resulting crippling interferes with an occupation and social life—has been the reason for denying patients the only chance of life.

The past decade has revolutionized this major amputation. The mortality rate has been decreased to below about 10%. Many patients have been able to wear a prosthesis and carry on gainful occupations, and two women who had this operation later became pregnant and delivered.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Dec. 1, 1951.

As to the possibility of cure, Gordon Taylor in 1946 wrote, "Final prognosis is most favorable in the infiltrating chondroma or chondrosarcoma, some cases being free from recurrence nearly ten years after amputation."

Several other patients with tumors of different histology have remained well for considerable periods—E. G. Girdlestone's patient with osteogenic sarcoma of the ilium survived 5 years; Harry Platt's patient with extraperiosteal sarcoma of the muscles of the upper thigh, 11 years, and his patient with diffuse osteoclastoma of the innominate bone, 17 years, and Davison's patient with carcinoma of the skin of the groin, 7 years.

My first patient with osteochondroma of the ilium is alive after 16 years.

REPORT OF CASES

The first three cases were reported in 1942, and only a brief description will be given.

CASE 1.—A 24-year-old man was admitted to the Barnard Free Skin and Cancer Hospital on April 8, 1935, for a tumor of the right hip of eight months' duration. Examination revealed a large tumor involving the wing of the right ilium, which was very painful. X-ray examination showed a tumor of the ilium which was pronounced osteogenic sarcoma. On April 18, with use of spinal anesthesia, a hindquarter amputation was done by Keen's technique, which is similar to Savario's. There was considerable shock, but a blood transfusion relieved the immediate danger.

The pathological report was osteochondroma. The patient was up and around on crutches within a few weeks and was discharged soon after. He has been seen repeatedly and is well at present.

CASE 2.—A 44-year-old woman was admitted to St. Luke's Hospital on Oct. 22, 1939, for pain in the right groin during the previous year. Pelvic examination revealed the uterus and adnexa involved in a semisolid mass. An x-ray examination showed a bony tumor arising from the brim of the pelvis. A biopsy on Oct. 23 revealed chondrosarcoma. On Nov. 8 a hindquarter amputation was performed according to the technique of Judin, which employs a posterior lateral flap, including the gluteus maximus muscle. Metastasis developed later, and the patient died two months postoperatively.

CASE 3.—The patient, a man aged 47, entered St. Mary's Hospital on May 12, 1941. Ten days before, while riding horseback, he received a severe jolt, striking the cantle of the saddle so hard that he thought he had broken his leg. X-ray examination revealed a tumor of the ischium involving the ramus and the margin of the acetabulum. On May 14 a hindquarter amputation was performed, using the technique of Judin. The pathological report was osteosarcoma. There was little shock, and the patient made a good recovery. He was discharged on June 5. He was seen on Dec. 9, 1941. He had gained weight and was going about on crutches and was driving his automobile. I never saw him again, but his physician reported his death about a year later from metastasis.

CASE 4.—The patient, a 46-year-old man was admitted to the hospital on Oct. 23, 1942. After a right hernia operation in November, 1938, his leg felt weak. This continued until February, 1939, when his leg gave way. He was admitted to St. John's Hospital; a diagnosis of fracture of the femur was made, and his leg was placed in a cast for four months. He was able to be about until 1941, when he noticed a swelling of the lateral side of the upper half of the femur, spreading later around the thigh. By April, 1942, it had involved the thigh and the knee. The pain was intense, and deep x-ray therapy was used to relieve pain but had no effect on growth. The right thigh at this time was 31 in. (78.7 cm.) in circumference, and its surface was covered with small petechial hemorrhages.

Family history revealed that the father died of carcinoma of the intestines and the mother of cardiac disease.

A hindquarter amputation was performed on Nov. 5, 1942. The pathological diagnosis was neuroblastoma. The patient was discharged on Dec. 17.

On Sept. 27, 1945, he was readmitted to the hospital. He died on Sept. 28 at 1:05 p.m.

CASE 5.—A 44-year-old man was admitted to the hospital on Feb. 2, 1944. About five months previously he had bumped his leg. Two months later he noticed pain in the left leg, from the thigh to the foot. He also noticed a swelling in the upper part of the thigh. Then several other lumps appeared. A biopsy specimen obtained March 25 was diagnosed as a fibrosarcoma, possibly neurogenic in origin. He had lost 12 to 20 lb. (5.4 to 9.1 kg.). X-ray study revealed an erosion of bone in the mid-third of the thigh and near the trochanter. There was no evidence of pulmonary metastasis. An interpelvic-abdominal amputation was carried out on Feb. 2.

The pathological diagnosis was fibrosarcoma of the left thigh muscles, with metastasis to the left inguinal lymph nodes and the pelvic bone. A roentgenogram of the chest taken on Feb. 25 showed no abnormalities. A roentgenogram taken on March 16 revealed areas in the right lung which were suggestive of metastatic involvement. The patient died on March 3, 1944, of metastasis.

CASE 6.—The patient, a man aged 40, was admitted to the Missouri Pacific Hospital on July 6, 1944. He had entered the hospital at Little Rock, Ark., on April 21, 1944, for pain in the arch of the left foot which came on 10 days before. A few days later a tumor mass developed in the muscles on the medial side of the left thigh. On May 25 a biopsy was made and the report was a rapidly growing sarcoma. In the middle of June there was a hemorrhage into the mass which necessitated incision and ligation of the bleeding vessels. There had been a 15 lb. (6.8 kg.) weight loss.

An x-ray study of the thigh showed a large mass in the soft tissues of the posterior and medial aspects of the mid-third of the shaft of the femur, with irregular areas of calcification in the mass. There was diminished bone density with cortical irregularity on the posterior and medial aspect. An x-ray of the chest showed no abnormality.

A hindquarter amputation was performed on July 24, 1944. One unit of blood and 1 unit of plasma were given. The patient's postoperative condition was good. The pathological diagnosis was neurosarcoma. His postoperative course was uneventful and he was discharged on Sept. 2.

In January, 1945, he was reported well; a month later we received word that he had died suddenly. Autopsy was not performed.

CASE 7.—A 19-year-old woman was admitted to the hospital on March 8, 1945. Eight years previously she had been treated for ulceration in the left leg. She was seen by Dr. Couglin, who diagnosed her condition as sarcoma and obtained a biopsy specimen which was diagnosed Ewing's tumor. Twenty radon seeds were implanted. A year later 40 radon seeds were implanted, and a year after that Dr. Sante began x-ray therapy. The patient also received Coley's fluid (a mixture of erysipelas and Bacillus prodigiosus toxins) for the first seven years of her illness.

The family history revealed that the father died of a cardiac condition, the mother died of influenza. She had two brothers living and well.

On March 3, 1945, a hindquarter amputation for a tumor of the left wing of the ilium was performed.

When examined on June 13, she complained of pain and discomfort in the abdomen. Abdominal metastasis was revealed on examination at the hospital. Treatment was palliative, and she was discharged on June 20.

CASE 8.—A man aged 44 was admitted to the hospital on May 5, 1948. The past history revealed that his right leg began paining in 1942, but the condition did not become serious until 1946, when his leg became sore and he began to limp on walking. A short time later an inguinal node began to enlarge, and a gland was excised. He was hospitalized, and in 1947 x-rays showed chondrosarcoma. He was treated and allowed up on crutches. On April 12, 1948, he fell and sustained a pathological fracture of the right femur. The leg then became enormously enlarged and edematous, and he entered the hospital for operation.

On May 8, x-rays showed extensive destruction of the proximal end of the right femur and acetabulum. A hindquarter amputation was performed on May 11, and the patient was discharged on May 26.

On Sept. 28, 1949, he was readmitted to the hospital. He had remained in good health until about one and one-half months previously when he noticed a swelling in the midportion of the old operation scar. Examination revealed a tumor mass arising from the pelvis on the right to a fingerbreadth below the umbilicus and a second tumor about 2 cm. in diameter and fluctuant arising to the right of the genitals.

Operation was performed on Oct. 1. An incision was made along the scar of the previous operation. The entire tumor mass with a portion of the bladder, the right spermatic cord, and the testicle was removed. A pathological diagnosis of chondrosarcoma was made. The patient was discharged on Nov. 20 and was referred to the roentgenologist, who advised therapy. The patient's condition improved. In March, 1952, his physician reported local recurrence.

CASE 9.—The patient, a 72-year-old man, was admitted to DePaul Hospital on April 4, 1949, for urinary retention. He had had difficulty in urinating for the past one to two years. On rectal examination the prostate was greatly enlarged; it was smooth and nontender. No tumor was present in the rectal wall. On April 27 a stab wound biopsy specimen was obtained. No cellular element was present. For the previous five years the patient had complained of pain in the left thigh and leg and was treated for sciatica. On April 23, x-ray examination revealed a mass in left side of the pelvis, with sclerotic and cystic changes in the ilium adjacent to the acetabulum. The bladder was displaced to the right. A postoperative pathological examination of the tumor revealed a large oval neoplasm on the inner aspect of the left side of the pelvis (ilium region of acetabulum). It was felt that this mass represented a primary bone tumor and was an osteogenic sarcoma. The heart was normal in size. The patient had generalized arteriosclerosis. X-rays showed old calcified pericarditis. No active pulmonary disease was present. A hindquarter amputation was performed on May 12. There was no evidence of shock. Wound healing was primary. The patient was discharged on June 3. A right ischial bursitis developed a year later which required excision. There was no evidence of cancer on pathological examination. The patient remained well and had been enjoying life. The right ischial bursitis became infected again and was excised in December, 1951; it then healed.

CASE 10.—The patient, a woman aged 52, had a mass in the right thigh below the inguinal region. Painful almost constant edema was present in the right leg for the previous month. The mass had existed for the previous six months and occurred after a herniorrhaphy.

The family history revealed that the mother's father and mother and a sister had died of carcinoma, and the mother died of influenza. The father was living and well. The patient had one child.

Physical examination showed a large tumor mass in the right femoral region. Operation was performed on April 26, 1949.

Biopsy revealed a firm solid tumor in the femoral triangle lateral to the femoral artery and vein, apparently involving the femoral vein. The tumor mass, 10 by 5 by 5 cm., was encapsulated. A regional lymph node was excised. The pathological report was fibrosarcoma.

Operation was performed on May 5; the wound was reopened and the tumor was excised. The pathological diagnosis was low-grade fibrosarcoma. On May 21 a hemipelvectomy was done with the patient under thiopental (pentothal®) sodium anesthesia. The pathological report was invasion of the lumen of the femoral vein by a tumor mass. The patient was discharged on June 6, 1949, and was seen frequently thereafter. To date there had been no evidence of recurrence, and she was planning to acquire a prosthesis.

COMMENT

I shall not go into the details of the operative technique, since it has been described by various surgeons. The type of operation must be suited to the particular case. In all my cases, with one exception, I have employed the posterior lateral flap, including the gluteal muscles, in order to maintain a blood supply to the skin flap. The ages of my patients have varied from 19 to 72 years, the latter being the oldest patient reported. Four are still living, 2 to 16 years after operation.

Many excellent contributions have been made to the subject and a recent one by Saint gives a very comprehensive review.

Brittain, of England, is to be complimented for his excellent paper and for his fine description of a prosthesis.

Ariel and Hark in a discussion of the low survival rate attributed it to the following factors: (1) the previous high operative mortality rate; (2) the use of irradiation for certain radioresistant tumors; (3) the frequent use of conservative surgical procedures before resorting to radical surgical resection, and (4) the attempts to retain partial function which have led surgeons to spare tissue which should have been resected.

Coley and Higginbotham, who reported 14 cases of hemipelvectomy, have analyzed their cases very carefully and have made some very pertinent statements. In the description of their cases they noted that prior to admission various procedures, such as biopsy, roentgen therapy, and incomplete attempts at removal of the tumor, had been carried out in 11 of the 14 cases. Wound infection, soft part recurrence, and alterations in the histological grade of the tumor made the radical operation more difficult and the complications more frequent, and, in some instances, many have affected the ultimate outcome adversely. Of the entire 14 cases, in only 3 no treatment was given prior to admission to the clinic.

They close their paper as follows:

> That in spite of the magnitude of the procedure and the great disability it causes in the early postoperative period, these patients tend to show a rapid recovery. Four of the patients are successfully wearing a prosthesis and have been able to resume gainful occupation and to lead normal social lives.

DISCUSSION

Dr. Robert A. Wise, Portland, Ore.: Dr. Leighton and Dr. Speed have been pioneers in this country in the development of this operative procedure. Dr. Speed first coined the name hemipelvectomy for this operation, which I prefer over all other designations. We have performed the operation on 10 consecutive patients at the Portland Veterans Administration Hospital for primary carcinoma of the bony pelvis or upper thigh. There has been no operative mortality.

As for indications for the procedure, it is perfectly evident that when one is dealing with a primary malignant tumor of the pelvic bones hemipelvectomy offers the only possibility for eradication. It is also indicated for patients with a primary malignant tumor of the upper third of the thigh because the procedure makes possible wide removal. For carcinomas of the upper thigh, hemipelvectomy should, I believe, be recommended instead of hip joint disarticulation.

The first slide illustrates what may happen after hip joint disarticulation for upper thigh carcinoma. This is a photograph of a patient who had a rhabdomyosarcoma of the upper third of the thigh, for which a hip joint disarticulation was performed. Eight months later he was admitted to our hospital with this massive local recurrence, and a hemipelvectomy was performed on the stump. How much better it would have been had the primary procedure been a hemipelvectomy.

We have developed two types of prostheses for patients to wear after hemipelvectomy. The first, illustrated in slide 2, consists of a canvas belt in which three leather-covered pads are placed. It serves as a support to the abdominal wall and takes the place of the removed buttock. This makes it possible for the patient to sit on an even keel, rather than on one side.

The second type is a walking prosthesis for patients who show no evidence of pulmonary metastasis after a period of one and one-half to two years. Slide 3 shows a patient wearing the prosthesis. He had a hemipelvectomy performed four and one-half years ago for osteochondrosarcoma of the ilium. He walks without the aid of crutches.

We are all greatly indebted to Dr. Leighton for his outstanding work in this field.

Dr. Herbert Davis, Omaha: I wish to emphasize the fact that this is not as difficult an operation to perform or as severe on the patient as it would seem. As described by Pack

and others, the operation is strictly an anatomical dissection, and, when done properly, there is very little blood loss and these patients get along remarkably well.

A girl, 16 years old, whom I saw in May, 1950, had a fibrosarcoma of the upper part of the thigh pressing against the pelvis. It was of three months' duration, 10 by 15 cm. in size, and with no metastases to the lung. We performed a hemipelvectomy. The highest postoperative temperature was 99.2 F., while it was as high as 100 to 102 F. before the operation. She continued to do very well and was up on the second postoperative day, and from the fourth day on was all over the place with crutches. She lived very happily for about three months but, unfortunately, pulmonary metastases developed and she died five months later.

The second case was that of a woman of 35 years who had had a series of operations for neurofibrosarcoma beginning in 1939, one then and one in 1941 for a recurrence of the tumor with local excision. In 1943 and in 1946 she was operated on by Dr. Adson at the Mayo Clinic, and each time the mass was extending higher. In one of the operations, part of the sacrum and a mass weighing 410 gm. was removed. I saw her in November, 1950, and attempted to remove the whole recurrent mass but found that it extended up into the pelvis. I then talked to her about a hemipelvectomy, and she wanted to go home over Christmas and decide about it. Early in January, 1951, she returned and we performed this surgery. She made a very uneventful recovery and at present is perfectly happy and well and getting around on crutches very comfortably.

With a little support under the buttock on that side, these patients get along much better than is expected and are happy.

Dr. John V. Goode, Dallas, Texas: I should like to mention one other condition in which this operation is indicated and that is in the treatment of malignant melanoma of the lower extremity. Dr. Ralph Bowers, of Memphis, believes that this is the operation of choice for such malignant melanomas, but it seems to me that it is too mutilating for the first treatment of a tiny melanoma, for example, of the toe. However, if the involved toe is removed for biopsy, and then if later there is no evidence of spread by the vascular system, any recurrence can be treated by this operation. It seems to me that this is the correct operation for malignant melanoma of the lower extremity because it is the most that can be done for such a lesion.

I have performed this operation twice—one of the patients had a malignant melanoma. I believe that when the iliac nodes are involved, no other operation is possible which would give as much chance as this one.

Dr. W. E. Leighton, St. Louis: In my paper I mentioned that there are several men who have done this operation, and Dr. Wise is responsible for bringing the value of this surgery to the attention of the profession in the United States. Dr. Brittain, in England, at about the same time was also emphasizing it, and showed pictures of a beautiful young woman who had been operated upon. He has almost a complete series of pictures of her walking back and forth. This case is one of the reasons for not worrying about crippling these patients.

HEMANGIOPERICYTOMA

Surgical Considerations

ROBERT A. WISE, M.D.
PORTLAND, ORE.

VASCULAR tumors have been of particular interest to surgeons for their unusual clinical and pathologic characteristics and because of the technical ingenuities frequently required for their removal. Stout's description of a previously unreported tumor of vascular origin, which he named hemangiopericytoma,[1] has caused increased interest in the subject.[2]

This tumor is composed of numerous capillary blood vessels around which are grouped masses of perivascular cells. Stout believes that these perivascular tumor cells derive from Zimmermann's pericytes,[3] those highly contractile, smooth, muscle-like cells which lie outside the capillaries. In distinction from hemangioendothelioma in which the tumor cells lie within the capillaries, the cells in hemangiopericytoma lie completely outside the vascular spaces. Their extraluminal situation can be demonstrated best by Laidlaw's silver stain, which brings the connective tissue fibers of the capillaries into sharp relief.

The tumor occurs as a firm encapsulated mass, at times with obvious blood vessel connection. In Stout's report of 34 cases, the majority of these tumors occurred in the subcutaneous or muscular tissues, but examples were also found in the retroperitoneum, mesentery, omentum, orbit, tongue, pericardium, diaphragm, ileum, and meninges. Evidently it can occur wherever capillaries exist.[4]

The tumor is slow in growing and may appear to follow an innocuous course; however, it is significant that in 38% of the patients local recurrence or distant

From the Surgical Service, Veterans Administration Hospital.

Read at the Fifty-Ninth Annual Meeting of the Western Surgical Association, Colorado Springs, Colo., Dec. 1, 1951.

Reviewed in the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the author are a result of his own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

1. Stout, A. P., and Murray, M. R.: Hemangiopericytoma: A Vascular Tumor Featuring Zimmermann's Pericytes, Ann. Surg. **116**:26-33, 1942.

2. Warren, S. and Ackerman, L. V.: Hemangiopericytoma of Retroperitoneal Space, J. Missouri M. A. **45**:380-382, 1948. Ault, G. W.; Smith, R. S., and Castro, A. F.: Hemangiopericytoma of the Sigmoid Colon, Surgery **30**:523-527, 1951. Kaplan, E. B.: Hemangiopericytoma of the Hand, Bull. Hosp. Joint Dis. **10**:69-74, 1949. Sims, C. F.; Kirsch, N., and MacDonald, R. G.: Hemangiopericytoma, Arch. Dermat. & Syph. **58**:194-205, 1948. Stout, A. P.: Tumors of Blood Vessels, Texas J. Med. **40**:362-365, 1944. Stout, A. P.: Sarcomas of the Soft Parts, J. Missouri M. A. **44**:329-334, 1947.

3. Zimmermann, K. W.: Der feinere Bau der Blutcapillaren, Ztschr. Anat. u. Entwcklngsgesch. **68**:29-109, 1923.

4. Stout, A. P.: Hemangiopericytoma: A Study of 25 New Cases, Cancer **2**:1027-1035, 1949. Stout, A. P., and Cassel, C.: Hemangiopericytoma of the Omentum, Surgery **13**:578-581, 1943.

metastasis developed. When more complete follow-up data are obtained, it may well be shown that the majority of hemangiopericytomas are malignant.

Herein are reported the cases of two patients with hemangiopericytoma which illustrate the clinical characteristics of the tumor and the surgical problems that may arise in its treatment.

REPORT OF CASES

CASE 1.—The patient, a white man aged 56, was admitted to the Veterans Administration Hospital, on Nov. 17, 1950, complaining of a nontender mass in the right axilla of four months'

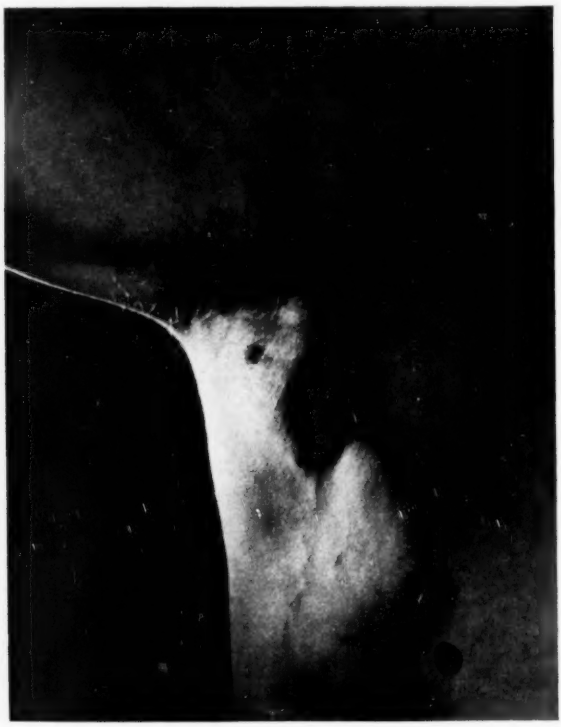


Fig. 1 (Case 1).—Hemangiopericytoma of axilla; note vascular channels in region of tumor.

duration. No increase in size had been noted. Examination revealed a firm, oval, freely movable, nontender mass 6 by 5 by 5 cm. situated beneath the right anterior axillary fold. Several large venous tributaries extended from the chest wall to the region of the tumor (Fig. 1). The red blood cell count was 4,450,000, the hemoglobin content 90%, and the white blood cell count 7,000, with 50% polymorphonuclear cells. The Wassermann and Kahn tests showed negative reactions. A roentgenogram of the chest was negative.

Operative Data (Nov. 29, 1950).—An incision was made in the right axilla, exposing the tumor which was found to lie beneath the pectoralis major and to extend to the apex of the axilla. The tumor was encapsulated and loosely attached to the axillary areolar tissue but more firmly attached to the under surface of the pectoral muscles. Many large venous channels, some 0.5 cm. in diameter, entered the mass at its periphery, and after ligation and division of

these vessels, the tumor was removed. Its gross appearance was that of a hemangioma, but in frozen section it appeared highly cellular, and the pathologist considered it to be malignant. Therefore, after extending the incision, a radical axillary dissection including removal of the pectoral muscles was performed.

Pathologic Report.—The gross specimen consisted of a tumor mass and surrounding axillary contents. The tumor was oval and measured 6 by 5.5 by 4.5 cm. It was encapsulated, firm, and lobulated, and in section appeared mottled gray-white in color. No areas of necrosis, hemorrhage, or calcification were present (Fig. 2). The axillary lymph nodes were not enlarged, were of the usual consistency and size, and histologically showed no evidence of tumor.

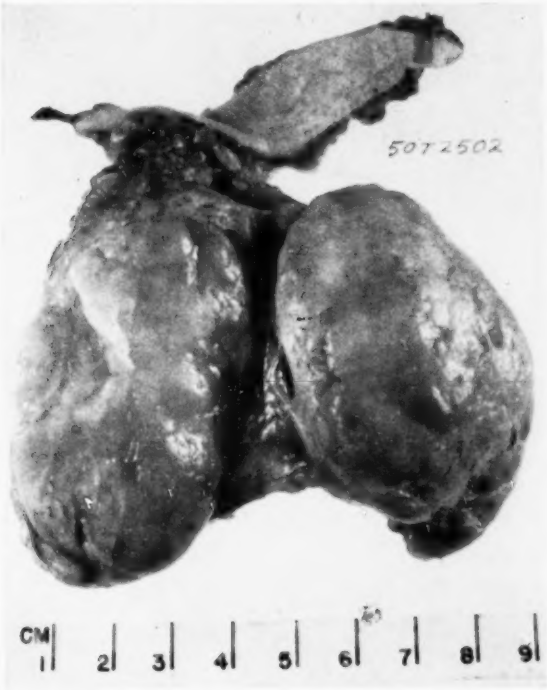


Fig. 2 (Case 1).—Gross specimen.

Microscopic Examination (Dr. Arthur Purdy Stout).—Sections were stained with combined Laidlaw-trichrome technique. The tumor was basically of vascular type, and the tumor cells were arranged in characteristic fashion about the capillaries. The tumor was interesting because in some places the tumor cells were almost free from reticulum fibers; in other areas almost every cell was surrounded by a fiber, and in extremely dense areas where the collagen predominated, the tumor cells and vessels had almost vanished. It is unusual, but not unknown, to find this degree of variation in hemangiopericytoma. It was believed that this tumor belonged to that class of neoplasms (Fig. 3).

The postoperative course was complicated by a wound infection but was otherwise uneventful.

Follow-Up Data (November, 1951).—The wound had healed with some contracture. There was no local recurrence or metastasis. A roentgenogram of the chest was negative.

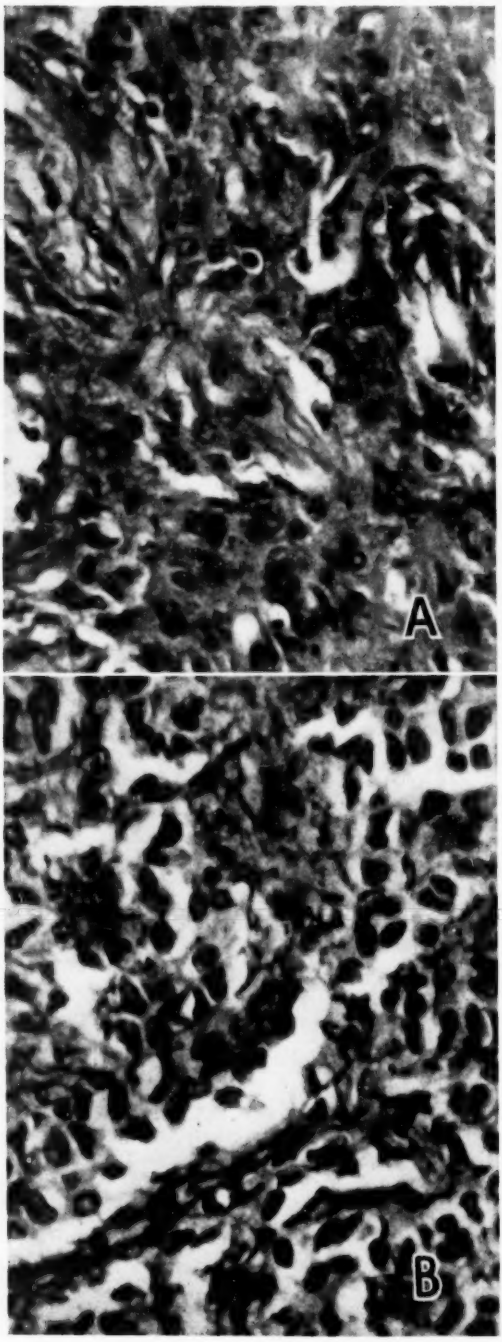


Fig. 3 (Case 1).—*A*, photomicrograph; hematoxylin and eosin stain. *B*, photomicrograph; Laidlaw silver stain.

COMMENT

The surgical problem presented in this case concerned the pathologic diagnosis of the tumor. Had it been benign, local excision would have been sufficient; if malignant, wide removal was indicated. The histologic appearance of the frozen section was that of a malignant tumor and radical removal with axillary dissection was carried out. The true nature of the neoplasm was determined only after study of the paraffin sections. It is possible that wide local removal without axillary dissection would have sufficed; however, it is significant that lymph-node metastasis occurred in one of Stout's cases and in Case 2 of this report. At present insufficient

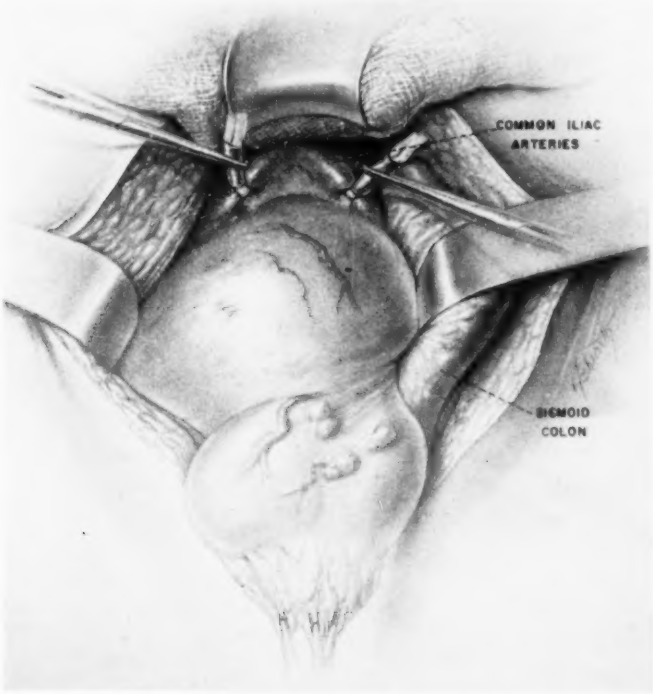


Fig. 4 (Case 2).—Drawing at operation; note occlusion of common iliac arteries.

data are available to warrant a recommendation of regional lymph-node dissection in patients with hemangiopericytoma, but with accumulated experience and follow-up studies, such dissection may prove advisable.

CASE 2.—The patient, a white man aged 43, was admitted to the Veterans Administration Hospital on Nov. 30, 1950. The past history revealed that he had been admitted to an Army station hospital in 1945. A mass extending from the umbilicus to the prostate was discovered. On March 29, 1945, a laparotomy was performed during which a highly vascular mass completely filling the true pelvis was found. A biopsy specimen was taken and the extensive hemorrhage resulting was controlled with difficulty by mattress sutures and muscle graft. The removed tissue was insufficient for pathologic diagnosis, and the patient was referred to an Army general hospital, and on May 14, 1945, six weeks later a second laparotomy was performed.

The tumor was again exposed, and, in attempting to free it, great bleeding was encountered which could not be controlled by clamps. Interrupted sutures were placed to control the hemorrhage, but these sutures cut through and additional bleeding resulted. Massive packing was required. Because of the severe hemorrhage no further procedure was performed. The patient received multiple blood transfusions, was given deep x-ray therapy, and was discharged.

Fig. 5 (Case 2).—Gross specimen.

Fig. 6 (Case 2).—Gross specimen, cross section.

On admission to the Veterans Administration Hospital five years later, the patient's only symptoms consisted of a sensation of pressure in the lower abdomen and urinary frequency. Abdominal examination revealed two healed lower abdominal scars. A large mass was palpable bimanually, extending from the rectum to the umbilicus. The red blood cell count was 3,600,000, the hemoglobin content 70%, and the white blood cell count 6,400, with 60% polymorphonuclear

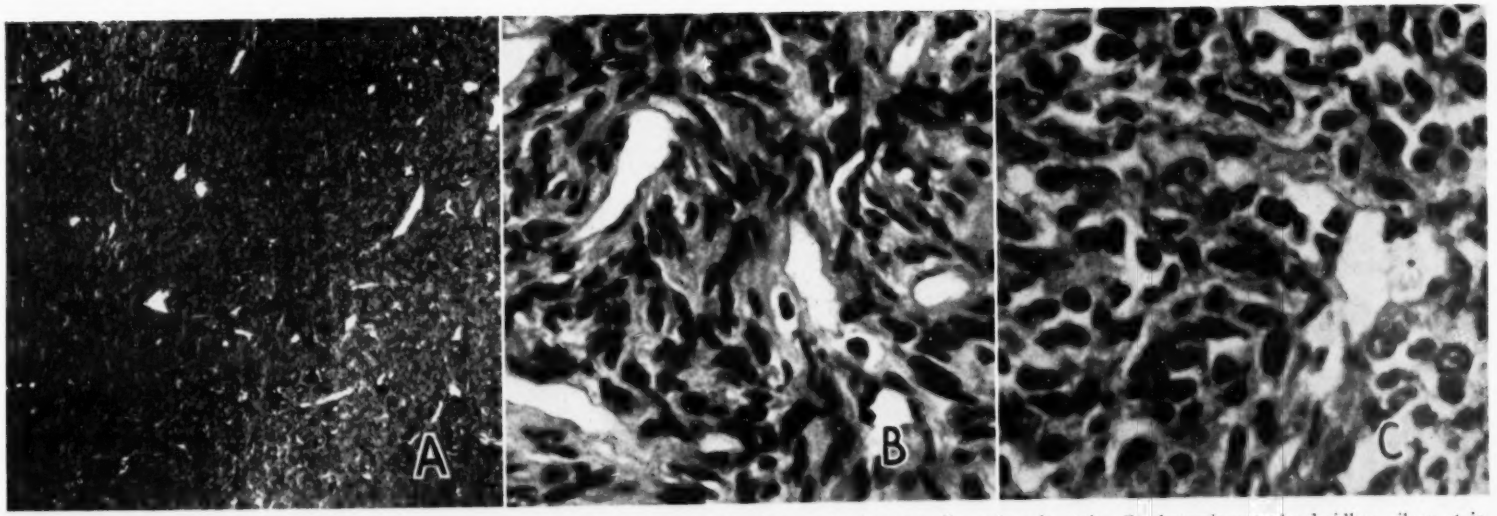


Fig. 7 (Case 2).—*A*, photomicrograph, low power; note vascular spaces. *B*, photomicrograph; hematoxylin and eosin stain. *C*, photomicrograph; Laidlaw silver stain.

cells. The blood Wassermann and Kahn tests gave negative reactions. A barium enema showed sharp deviation of the sigmoid colon laterally and anteriorly, with evidence of extrinsic pressure. Retrograde pyelography revealed anterior displacement of both ureters with narrowing at the pelvic brim and a moderate degree of hydronephrosis. A roentgenogram of the chest was negative for metastasis.

Operative Data (Jan. 10, 1951).—On opening the peritoneum an immense, encapsulated, tense, highly vascular tumor was found completely filling the pelvis and extending upward to the umbilicus. Many large vascular channels entered the tumor from the great omentum, the mesentery of the sigmoid colon, and the anterior wall of the bladder. The liver was not enlarged and showed no evidence of tumor. At operation the lower two-thirds of the greater omentum was transected and divided, leaving the lower section attached to the tumor. The vascular attachments to the mesentery of the sigmoid colon were divided after individual ligation of the

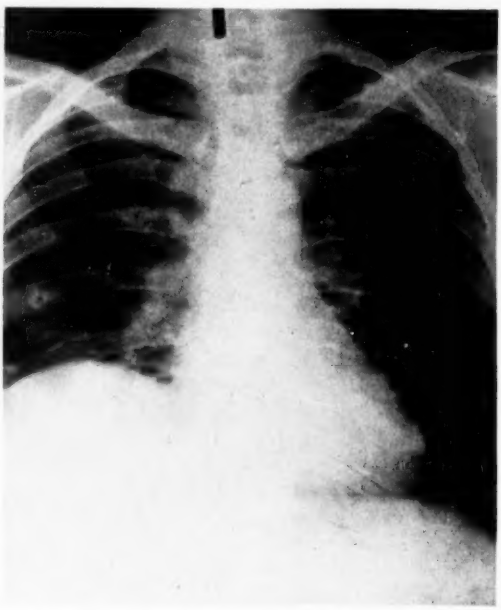


Fig. 8 (Case 2).—Roentgenogram of the chest taken eight months following operation; note pulmonary metastasis.

large vascular channels. The highly vascular tissue between the anterior wall and the bladder was divided after careful ligation. As the pelvis was approached, it was found impossible to place the examining hand between the tumor and the lateral pelvic walls or the sacrum. The right and left common iliac arteries were exposed and temporary controlling tapes placed about them (Fig. 4). It was noted that when both common iliac arteries were occluded, the pelvic tumor became less tense and markedly smaller. Posteriorly the tumor was not attached to the sacrum or the rectum but deep in the pelvis was adherent to both seminal vesicles and to the prostate gland. After isolation and protection of the ureters, the lateral wall attachments were ligated and divided, and the tumor was separated from the seminal vesicles and removed. The controlling tape was removed from the right common iliac artery thus identifying many uncontrolled divided arterial branches on the lateral pelvic wall which were then individually ligated. A similar procedure was followed on the left side. Occlusion of both common iliac arteries was maintained for 1 hour and 10 minutes.

Pathologic Report.—The tumor weighed 990 gm. and measured 20 by 11 by 10.5 cm. It was trilobed and encapsulated, and the external surface contained many large vessels. In sectioning the tumor bulged above the cut edge of the capsule. The upper lobe was gray-white in color, firm, and partially calcified. The middle lobe was hemorrhagic, and the third lobe was yellow in color and of a rubbery consistency. Both the upper and the lower lobe showed innumerable vascular spaces, while only a few such spaces were present in the middle lobe (Figs. 5 and 6).

Microscopic Examination (Dr. Arthur Purdy Stout).—The Laidlaw silver reticulin impregnation showed that in many areas the tumor appeared to be primarily vascular, with a thick layer of cells oriented around the vascular spaces outside the reticulin sheath. These cells seemed like pericytes. Adjacent areas had a comparable arrangement except that the vessel lumens seemed to have been destroyed by fibrosis. Finally, these adjoined still other areas in which all trace of the vessels had vanished. If these areas were observed without reference to the vascular parts, one could have no suspicion of the tumor's basic vascular pattern. On the whole, therefore, it was felt that this tumor should be classified as a hemangiopericytoma (Fig. 7).

The postoperative course was uneventful, and the patient was discharged on the 28th postoperative day.

Follow-Up Data.—The patient was well for approximately six months following his discharge. In August, 1951, he entered the Veterans Administration Hospital at Fort Harrison, Mont. An enlarged liver was palpable, and a roentgenogram of the chest showed evidence of pulmonary metastasis (Fig. 8). He followed a downhill course and died on Sept. 29, 1951. An autopsy revealed extensive metastasis to the liver, the retroperitoneal and mediastinal lymph nodes, and the lungs.

Comment.—Satisfactory control of the innumerable vascular channels entering the huge tumor constituted the compelling surgical problem in this case. After individual ligation and division of the vessels supplied by the omentum and sigmoid mesentery, there remained the large blood channels derived from the lateral pelvic walls. Should there be a predominant arterial element in these channels, temporary occlusion of both common iliac arteries should aid in their control. After occlusion was effected, an astonishing change occurred in the tumor. Previously tense and noncompressible, it then became soft and compressible. It was then possible to place the hand between the tumor and the hollow of the sacrum or between the tumor and one lateral pelvic wall, maneuvers previously impossible and, as such, the cause of considerable concern. After the tumor was removed, release of one common iliac artery at a time made possible identification and ligation of divided arterial channels on one pelvic wall while similar ones were controlled on the other.

The slow growth of hemangiopericytoma is well illustrated in this case. It is known that this large tumor had been present for five years, during which time a very slight increase in size had occurred. It is probable that it had been present for many years. The necessity of early removal of a hemangiopericytoma before metastasis occurs is emphasized by this case.

SUMMARY

Two examples of a newly described vascular tumor, hemangiopericytoma of Stout, are reported.

The value of temporary occlusion of both common iliac arteries in the removal of a pelvic hemangiopericytoma is demonstrated.

The importance of early and complete removal of these tumors is emphasized.

Dr. Arthur Purdy Stout studied the histologic sections and gave permission to publish his reports.

DISCUSSION

DR. LEROY B. SHERRY, Pasadena, Calif.: I have one case to report and a question.

In 1942 a dentist in his middle 50's presented himself with a vascular tumor in the right popliteal space. This was removed and was diagnosed as hemangiosarcoma. A few months later he returned with the same type of tumor in the right groin, and some months after that he had the same type of tumor removed from the anterior chest wall. A year or two later a large tumor of the same type was removed from the left axilla. Subsequently, a tumor of the distal end of the left clavicle was removed. A few months later paralysis set in, and the same type of tumor pressing on the cord was removed from the thoracic spine. The patient died in 1950. This tumor has since been evaluated and proved to be a hemangiopericytoma and has been accepted as such by Stout.

Three months ago a man presented himself with a small tumor in the hypothenar space of the left hand. It was removed under anesthesia by one of the surgeons and diagnosed as hemangiopericytoma—a diagnosis also accepted by Dr. Stout, with recommendation of amputation. The question in my mind is whether the recommendation of amputation of the left hand and midforearm for a tumor of this type is justified. It may be that those persons who understand carcinoma can give us the answer.

DR. ROBERT A. WISE, Portland Ore.: We do not know the answer yet as to the advisability of radical surgery for these newly described vascular tumors because of the inadequate follow-up reports in the majority of the published cases of hemangiopericytoma. I do make a plea for all members of this Association to review the slides of the vascular tumors they have removed in order to determine whether or not some of them may have been hemangiopericytomas rather than hemangioendotheliomas. Should they be hemangiopericytomas, a report of the follow-up findings would be extremely helpful.

CLINICAL PHOTOGRAPHY

AN ESTABLISHED SERVICE TO THE MEDICAL PROFESSION

- SURGICAL DRAWINGS
- PHOTOMICROGRAPHY
- COPIES FROM BOOKS
- COLOR AND BLACK AND WHITE
- LANTERN SLIDES
- MOULAGES
- PHOTOGRAPHS OF PATIENTS
- MOTION PICTURES
- X-RAY PRINTS
- PROMPT ATTENTION TO MAIL ORDERS

MARTIN HAGGETT

220 WEST 42nd STREET N. Y. C. 18 WIsconsin 7-2602

PAMPHLETS ABOUT Vision

Whom Shall I Consult About My Eyes? F. T. Jung. 8 pages. 10 cents.

Eyes—Right! Audrey McKeever. 14 pages. 15 cents.

How to Save Your Eyes. Cleo Du Bois. 4 pages. 10 cents.

Should Your Child Wear Glasses? J. Robert Burke. 12 pages. 15 cents.

Color Blindness. Dean Farnsworth and Conrad Berens. 2 pages. 10 cents.

New Eyes for Old (Corneal Transplant). Max Fine. 10 pages. 20 cents.

Glaucoma. Arthur A. Knapp. 12 pages. 15 cents.

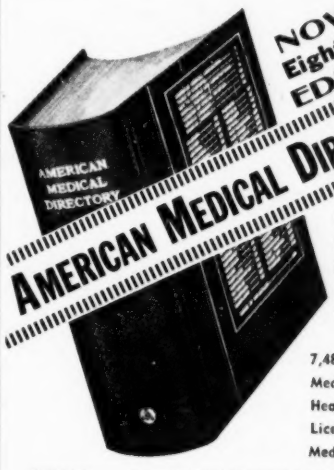
Cataract. Abram B. Bruner. 12 pages. 15 cents.

Visual Efficiency. Henry A. Imus. 8 pages. 10 cents.

Please remit with order

AMERICAN MEDICAL ASSN.

535 N. Dearborn St. • Chicago 10



NOW Eighteenth EDITION

AMERICAN MEDICAL DIRECTORY

Data on ..... 219,677 Physicians in United States and Canada

7,482 Hospitals
Medical Societies
Health Officers
Licensing Boards
Medical Schools

BRINGS you over 325,000 changes in the 8-year period since the last edition . . 250,000 changes of address . . 51,984 new physicians . . 28,000 deaths—plus other changes in specialties and certifications . . by Examining Boards in Medical Specialties.

Complete and authoritative. New statistics on distribution of physicians. Own your own copy of this valuable source book—keep it always at hand!

American Medical Association
535 N. Dearborn St.
Chicago 10, Illinois

• • PRICE $25.00

"Pressoplast"

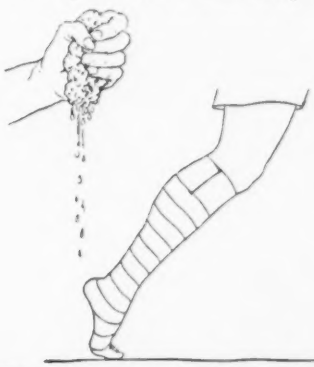
Natural or Flesh Colored

Adhesive Cotton E-L-A-S-T-I-C Bandage

"Contura" —BANDAGE

skin protecting medicated

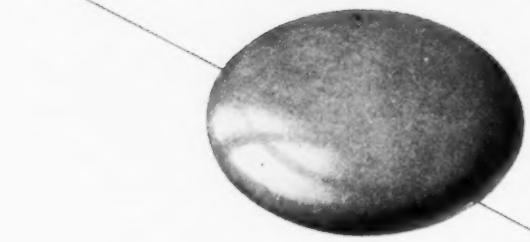
Write for Literature and Reprints



MFRS. OF ELASTIC BANDAGES AND DRESSINGS

Medical Fabrics Co., Inc.

10 Mill Street Paterson 1, N. J.



new convenience

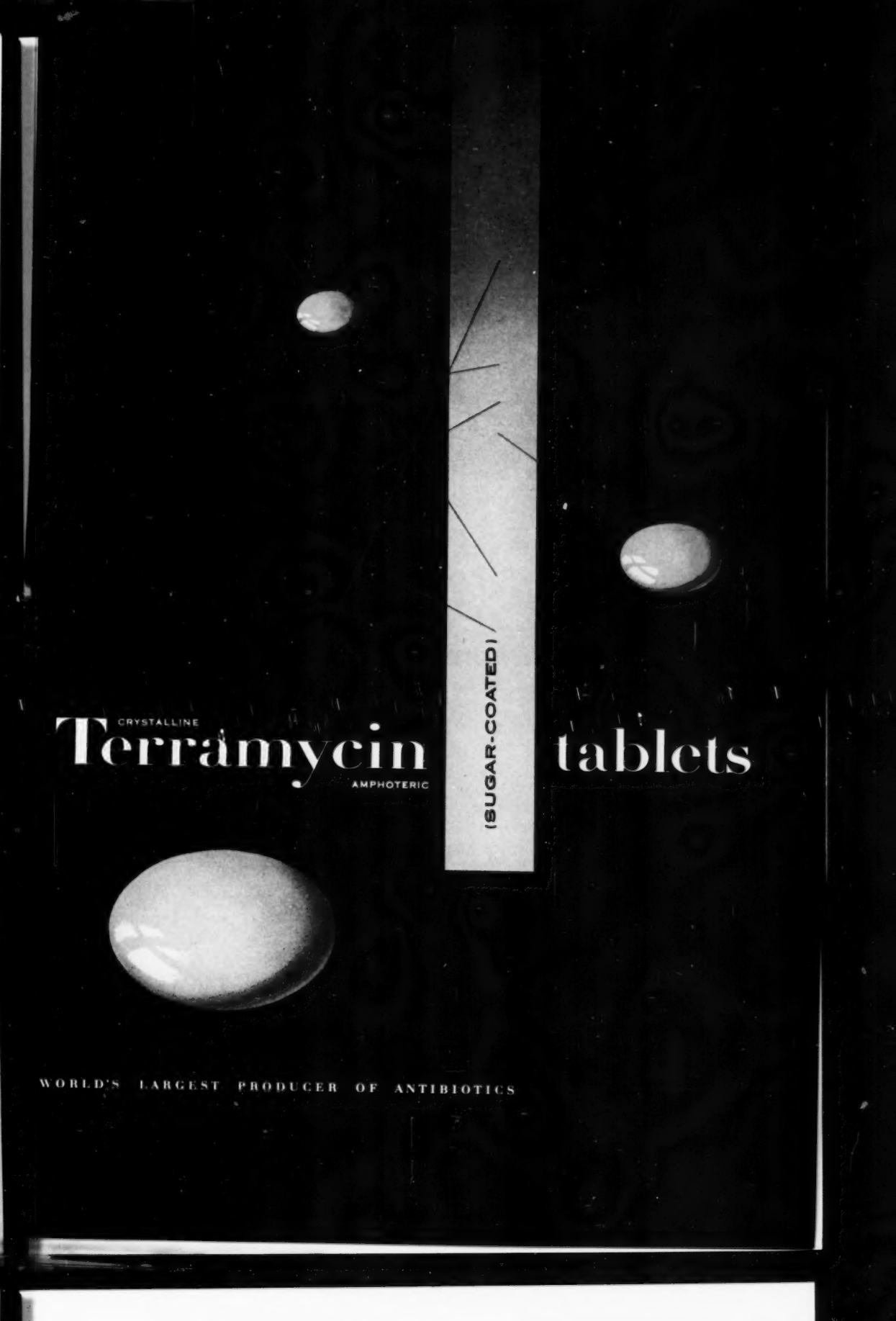
in broad-spectrum therapy

Easily swallowed, sugar-coated Terramycin Tablets introduce new flexibility in prolonged courses of administration and are particularly suited to effective, well tolerated therapy among patients preferring tablets to other oral forms.

Supplied: 250 mg. tablets, bottles of 16 and 100; 100 mg. and 50 mg. tablets, bottles of 25 and 100.

ANTIBIOTIC DIVISION, CHAS. PFIZER & CO., INC.
Brooklyn 6, N.Y.

Pfizer


CRYSTALLINE
Terramycin
AMPHOTERIC
(SUGAR-COATED)
tablets
WORLD'S LARGEST PRODUCER OF ANTIBIOTICS

AND NOW THROUGH

A New Grip on Problems of Industrial Medicine

A Journal Designed For Your Interests

A. M. A. Archives of INDUSTRIAL HYGIENE and OCCUPATIONAL MEDICINE

Edited by men of outstanding reputation in the fields of industrial health and preventive industrial hygiene: Prof. Philip Drinker, Boston, Chief Editor; Robert Kehoe, M.D., Cincinnati; James Sterner, M.D., Rochester, N. Y.; Frank Patty, Detroit, Mich.; Theodore Hatch, Pittsburgh; Frank Princi, M.D., Cincinnati; Fenn E. Poole, M.D., Glendale, Calif.; William A. Sawyer, Rochester, N. Y.

Covering the research and field aspects of industrial hygiene and the clinical and medical aspects of occupational industrial health programs.

Merging the best features of *Occupational Medicine* and *The Journal of Industrial Hygiene and Toxicology.*

Integrated closely with the activities of the Council of Industrial Health of the A. M. A. and the American Industrial Hygiene Association.

A Better and More Useful Journal of Industrial Medicine!

Such is the result which the Editorial Board of A. M. A. Archives of INDUSTRIAL HYGIENE and OCCUPATIONAL MEDICINE has achieved by combining parallel publications.

To the thousands of physicians who are directly or indirectly concerned today with medicine in industry, the new journal will bring reports of the continuing and important developments in the field, with original articles covering problems and day to day experiences of physicians in industry; an excellent abstracting service similar to that carried in the *Journal of Industrial Hygiene and Toxicology;* additional foreign journal abstracting; reviews.

Whether servicing industrial firms, attending employees, applying to general practice some of the findings of industrial medicine, or merely *watching* this expanding field, you will want to receive this vital new periodical.

AMERICAN MEDICAL ASSOCIATION
535 N. Dearborn Street, Chicago 10

Enter my subscription to A. M. A. Archives of INDUSTRIAL HYGIENE and OCCUPATIONAL MEDICINE to start *with the next issue.* Per year, $8.00 in U. S. (Canadian, $8.40; Foreign, $9.00).

I enclose check..... Please bill me.....

Name.....

Address.....

Only BEAVER
makes replaceable bent blades

BEAVER BENT BLADES permit better technique in deep operations such as arthroplasty, semi-lunar cartilage and laminectomy. Also in hysterectomy, gall bladder and thorax. No. 14 (sharp all around), No. 16 (sharp on one edge only), and No. 18 (sharp on two edges with a safe point). ALL BEAVER BENT BLADES are rigidly tested for strength before leaving the factory — they fit all BEAVER KNIFE HANDLES.

RUDOLPH BEAVER
WALTHAM 54, MASS., U. S. A.

SURGICAL KNIVES BY
Rudolph
Beaver

YARDSTICK OF QUALITY

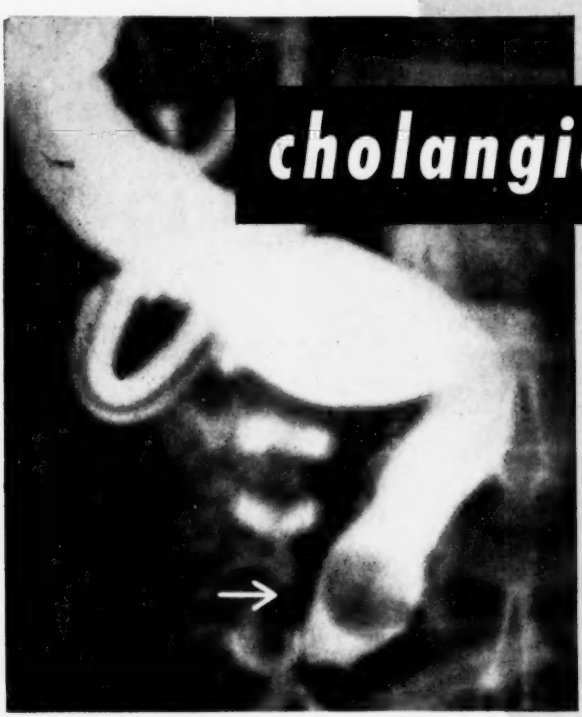
...more than 20 years long!

The name *Deknatel* has been recognized as the Yardstick of Quality in surgical silk for more than 20 years. The reason for this lies in the unusual tensile strength of the suture material — the constant uniformity of diameter — and its extreme pliability. Deknatel Surgical Silk is moisture and serum resistant — non-absorbable, non-capillary, and non-slipping. The unvarying quality and uniformity of Deknatel Sutures have won the confidence of surgeons everywhere. J. A. Deknatel & Son, Queens Village 29, L. I., N.Y.

Sold by Surgical-Hospital Supply Houses.

DEKNATEL SURGICAL SUTURES
The First and Still The First

OTHER DEKNATEL PRODUCTS—DEKNATEL SURGICAL NYLON, MINIMAL-TRAUMA NEEDLES WITH ATTACHED SUTURES, NAME-ON BEADS



cholangiography

Cholangiogram with Diodrast 35% showing stone in distal end of common duct. Illustration, courtesy of Dr. J. Buckstein, author of "The Digestive Tract in Roentgenology" (Lippincott, 1948) in which a whole chapter is devoted to this procedure.

Diodrast®

35% SOLUTION

BRAND OF IODOPYRACET INJECTION

For Clear Visualization of the Biliary Tract

Also Urinary Tract, Arteries, Veins

Ampuls of 10, 20 and 30 cc.

Simplified Technic

For a detailed discussion of a simple fractional method for cholangiography postoperatively or operatively write for illustrated pamphlet.

Winthrop-Stearns INC.

NEW YORK 18, N. Y. WINDSOR, ONT.

Diodrast, trademark reg. U. S. & Canada

Easy Roentgenologic Detection of "the 10 to 18 per cent of stones left behind after common duct exploration"[1]

"Since 1934 we have employed visualizing cholangiograms in all operations on the extrahepatic biliary system. More than 1700 studies have been made and from this experience much information has been obtained. Operative cholangiograms demonstrate congenital aberrations and anatomic displacements of the extrahepatic biliary system; determine patency of the ductal system; note number and position of offending calculi; designate functional status of the sphincter of Oddi; outline fistulous communications; visualize bile reflux into the pancreatic ducts; detect intrusions of neoplasms which impinge on the large bile ducts or originate in the ampulla of Vater; and visualize dilatation, sacculation or diverticular enlargements of the bile ducts themselves. Such exact information permits the surgeon to select the operative procedures best suited to alleviate existing pathologic abnormalities."[2]

1. Byrne, R. V.: *Amer. Jour. Surg.*, 78:514, Oct., 1949.
2. Hicken, N. F., Stevenson, U. L., Franz, B.J., Crowder, Earl: *Amer. Jour. Surg.*, 78:347, Sept., 1949.